BEST AVAILABLE COPY

FIG. 1

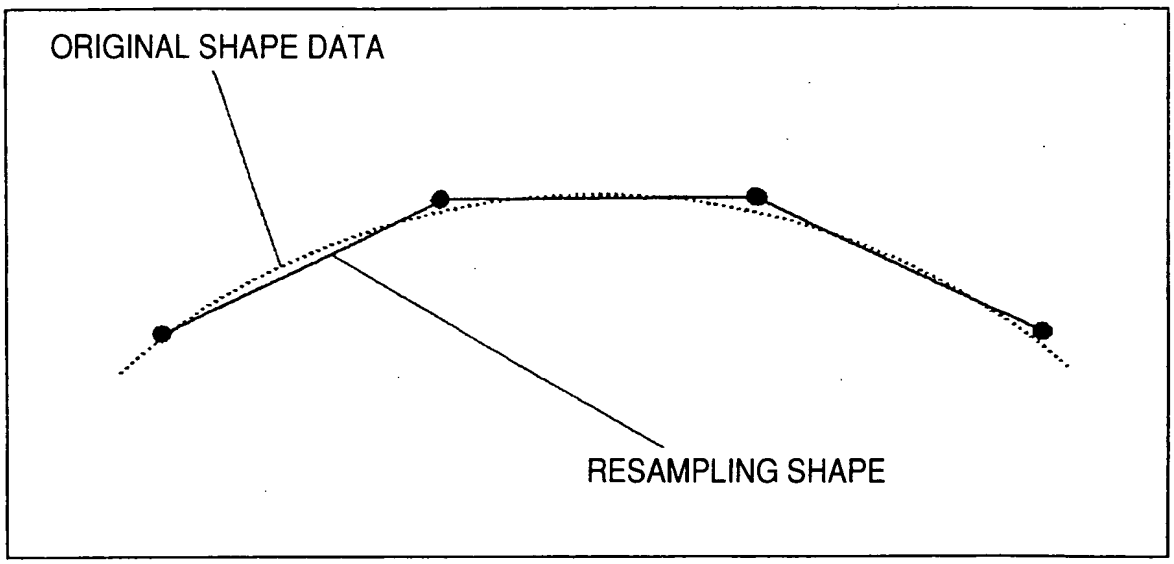


FIG. 2(a)

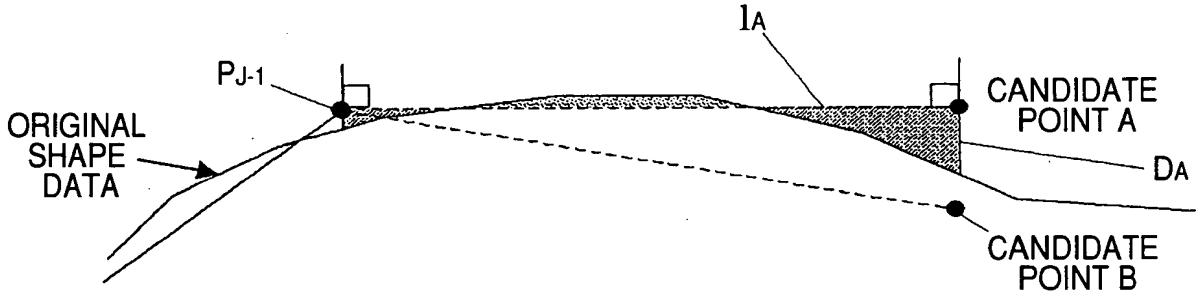

lA
PJ-1
ORIGINAL SHAPE DATA
CANDIDATE POINT A
DA
CANDIDATE POINT B

FIG. 2(b)

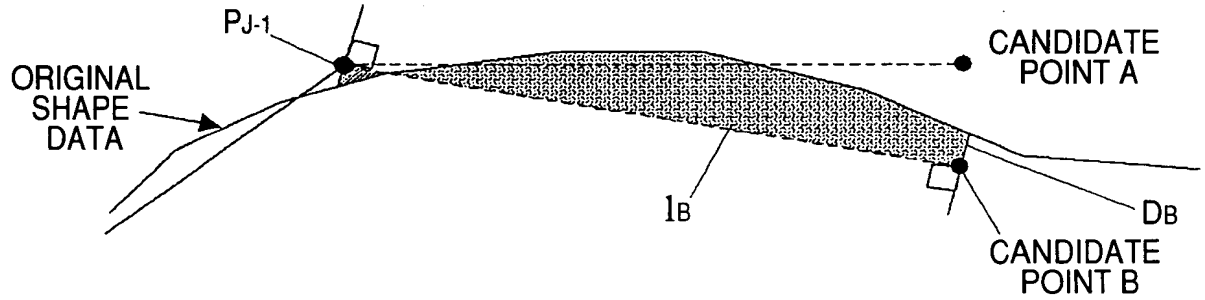

PJ-1
ORIGINAL SHAPE DATA
CANDIDATE POINT A
lB
DB
CANDIDATE POINT B

FIG. 3

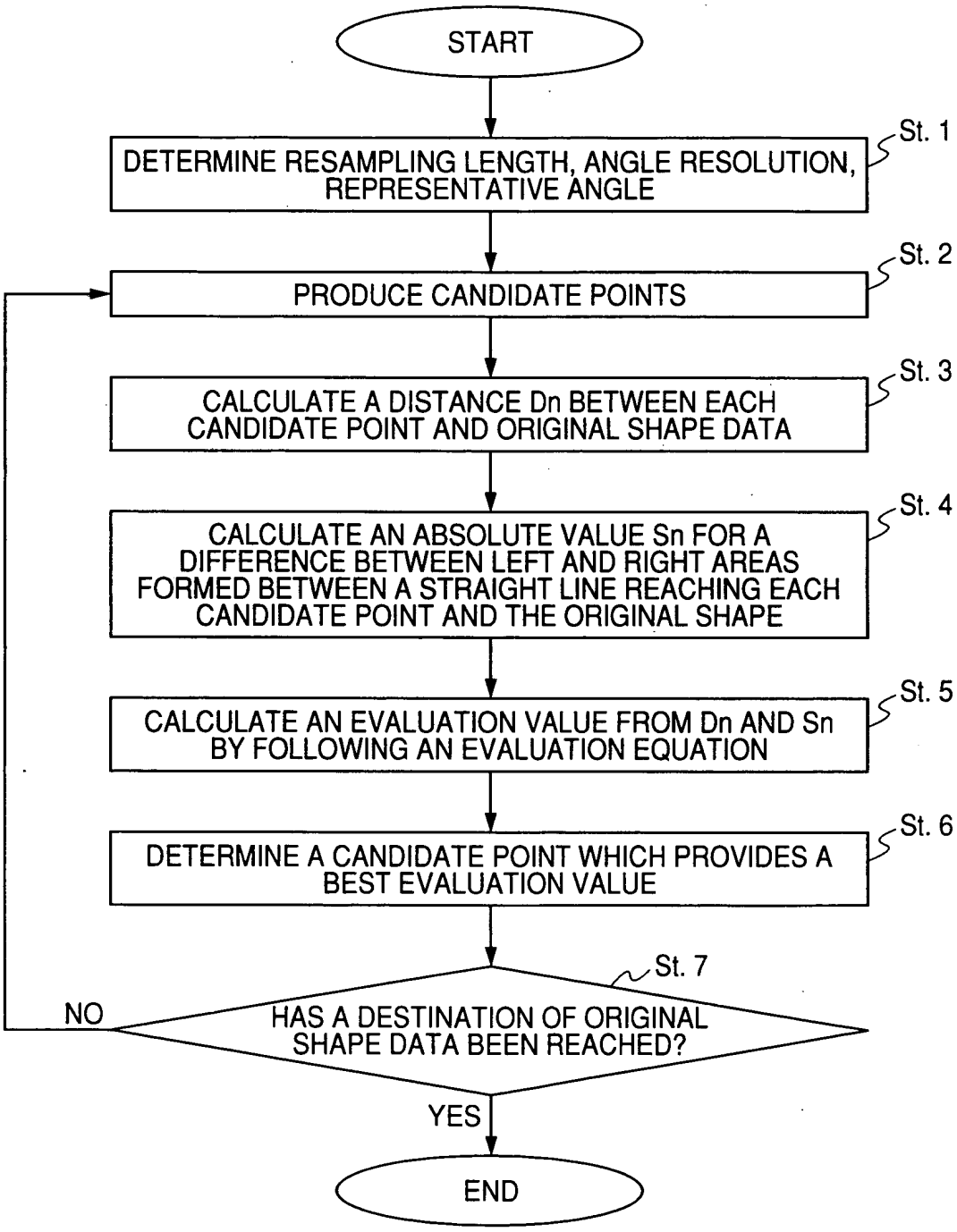

START
DETERMINE RESAMPLING LENGTH, ANGLE RESOLUTION, REPRESENTATIVE ANGLE
St. 1
PRODUCE CANDIDATE POINTS
St. 2
CALCULATE A DISTANCE Dn BETWEEN EACH CANDIDATE POINT AND ORIGINAL SHAPE DATA
St. 3
CALCULATE AN ABSOLUTE VALUE Sn FOR A DIFFERENCE BETWEEN LEFT AND RIGHT AREAS FORMED BETWEEN A STRAIGHT LINE REACHING EACH CANDIDATE POINT AND THE ORIGINAL SHAPE
St. 4
CALCULATE AN EVALUATION VALUE FROM Dn AND Sn BY FOLLOWING AN EVALUATION EQUATION
St. 5
DETERMINE A CANDIDATE POINT WHICH PROVIDES A BEST EVALUATION VALUE
St. 6
St. 7
HAS A DESTINATION OF ORIGINAL SHAPE DATA BEEN REACHED?
NO
YES
END

FIG. 4

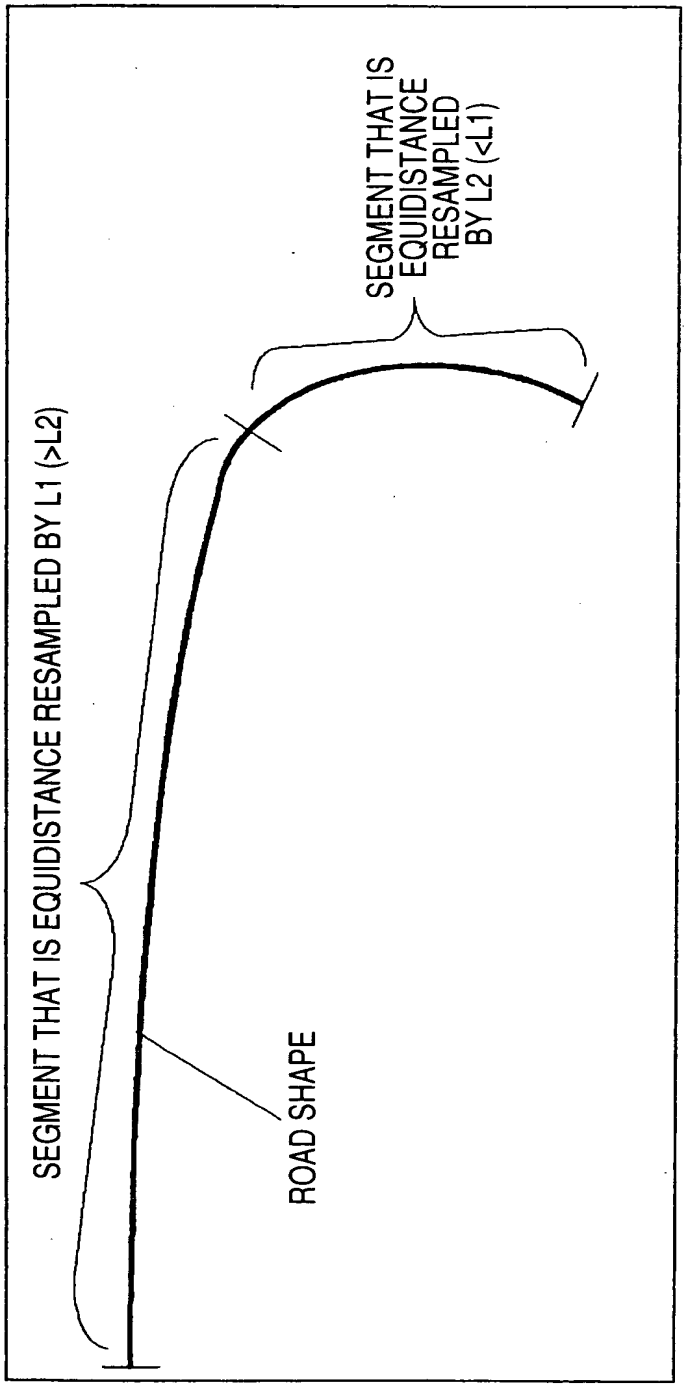

SEGMENT THAT IS EQUIDISTANCE RESAMPLED BY L1 (>L2)
SEGMENT THAT IS EQUIDISTANCE RESAMPLED BY L2 (<L1)
ROAD SHAPE

FIG. 5(b)

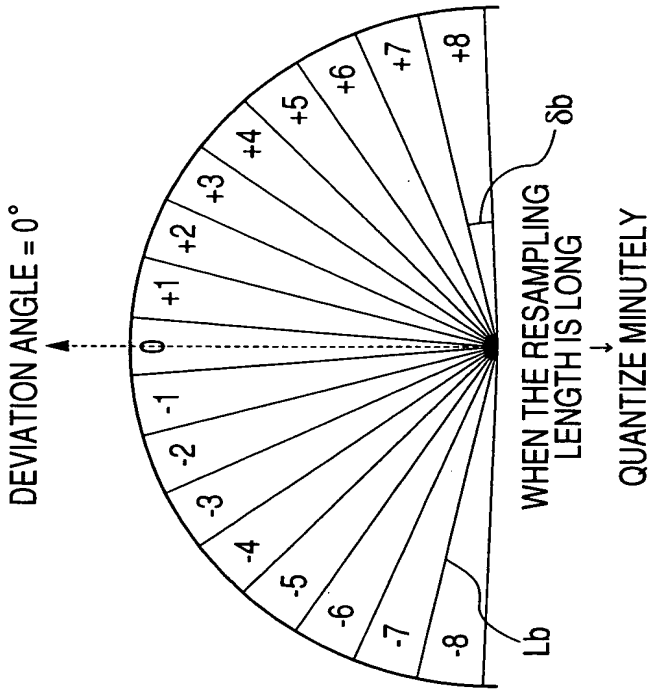

DEVIATION ANGLE = 0°
0
+1
+2
+3
+4
+5
+6
+7
+8
-1
-2
-3
-4
-5
-6
-7
-8
δb
Lb
WHEN THE RESAMPLING LENGTH IS LONG
QUANTIZE MINUTELY

FIG. 5(a)

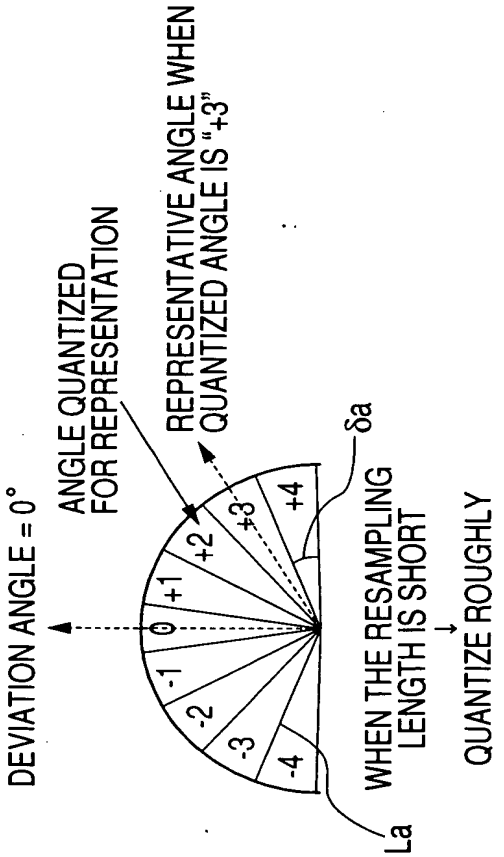

DEVIATION ANGLE = 0°
ANGLE QUANTIZED FOR REPRESENTATION
REPRESENTATIVE ANGLE WHEN QUANTIZED ANGLE IS "+3"
0
+1
+2
+3
+4
-1
-2
-3
-4
δa
La
WHEN THE RESAMPLING LENGTH IS SHORT
QUANTIZE ROUGHLY

FIG. 6

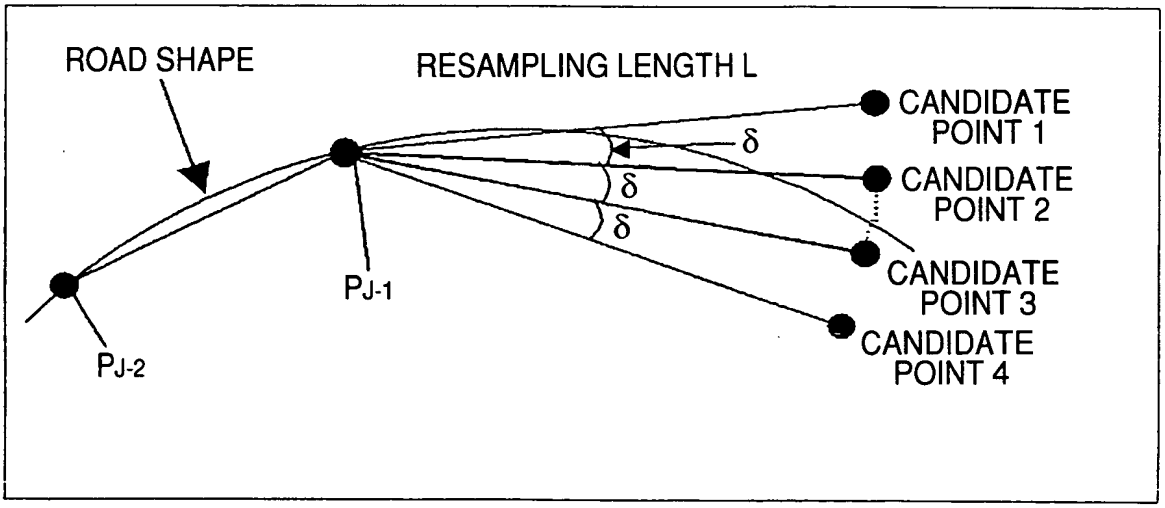

ROAD SHAPE
RESAMPLING LENGTH L
CANDIDATE POINT 1
CANDIDATE POINT 2
CANDIDATE POINT 3
CANDIDATE POINT 4
δ
δ
δ
PJ-1
PJ-2

FIG. 7(a)

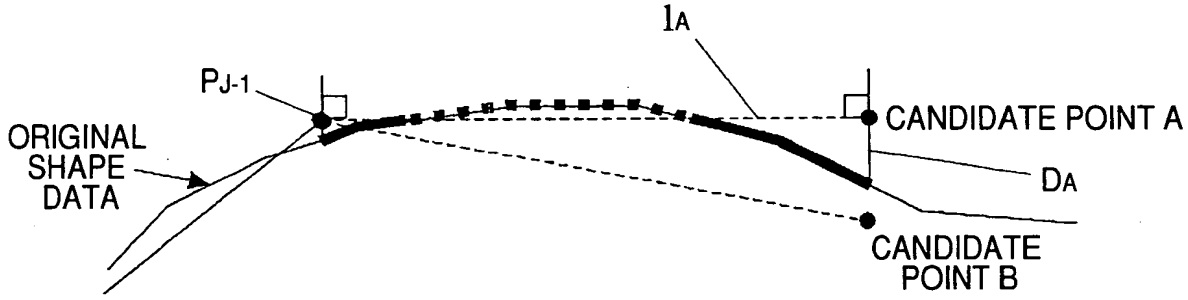

lA
PJ-1
CANDIDATE POINT A
ORIGINAL SHAPE DATA
DA
CANDIDATE POINT B

FIG. 7(b)

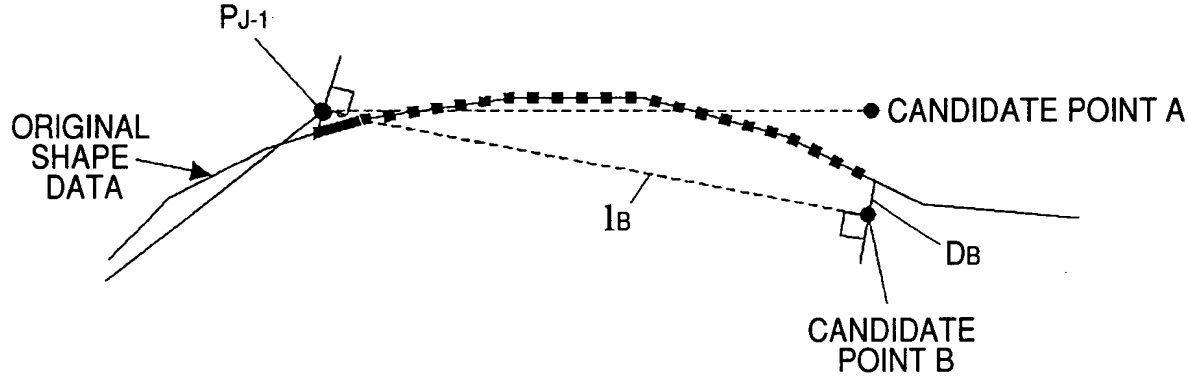

PJ-1
CANDIDATE POINT A
ORIGINAL SHAPE DATA
lB
DB
CANDIDATE POINT B

FIG. 8

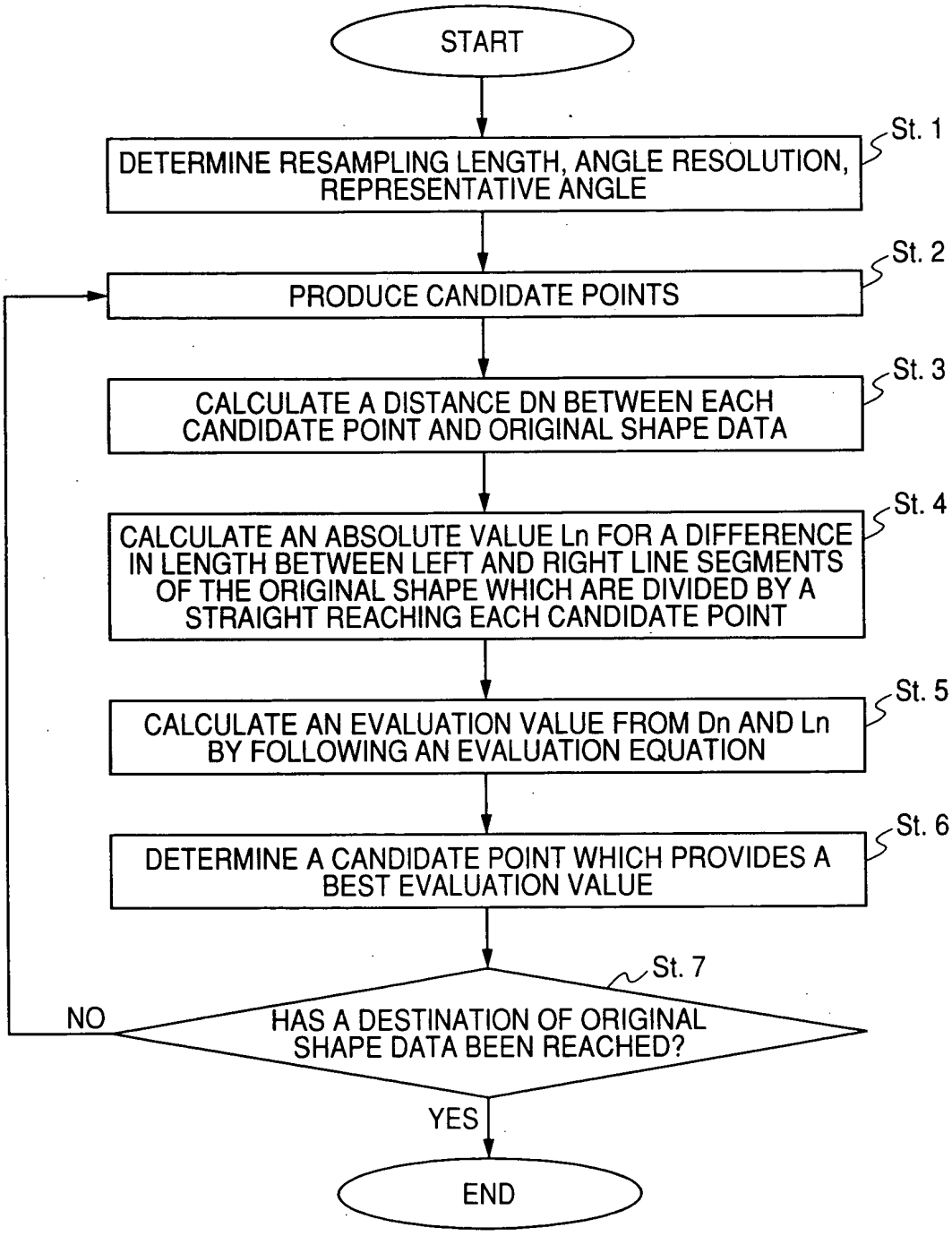

START
DETERMINE RESAMPLING LENGTH, ANGLE RESOLUTION, REPRESENTATIVE ANGLE
St. 1
PRODUCE CANDIDATE POINTS
St. 2
CALCULATE A DISTANCE DN BETWEEN EACH CANDIDATE POINT AND ORIGINAL SHAPE DATA
St. 3
CALCULATE AN ABSOLUTE VALUE Ln FOR A DIFFERENCE IN LENGTH BETWEEN LEFT AND RIGHT LINE SEGMENTS OF THE ORIGINAL SHAPE WHICH ARE DIVIDED BY A STRAIGHT REACHING EACH CANDIDATE POINT
St. 4
CALCULATE AN EVALUATION VALUE FROM Dn AND Ln BY FOLLOWING AN EVALUATION EQUATION
St. 5
DETERMINE A CANDIDATE POINT WHICH PROVIDES A BEST EVALUATION VALUE
St. 6
HAS A DESTINATION OF ORIGINAL SHAPE DATA BEEN REACHED?
St. 7
NO
YES
END

FIG. 9(a)

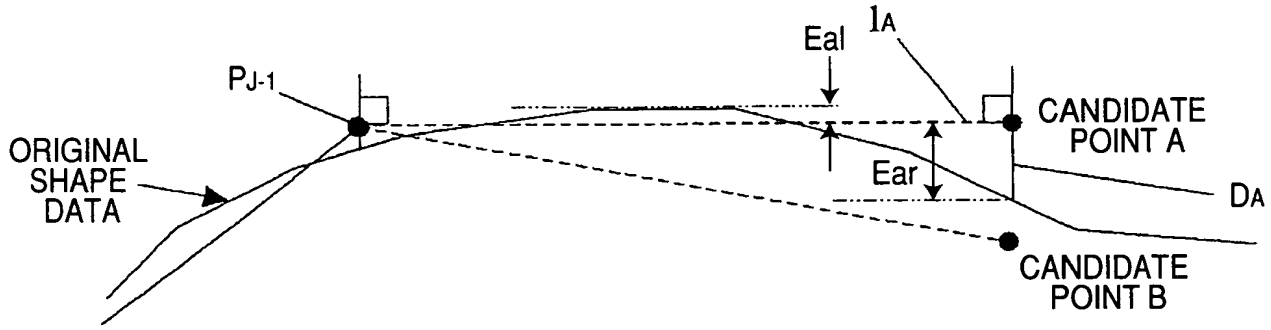

PJ-1
ORIGINAL SHAPE DATA
Eal
lA
Ear
CANDIDATE POINT A
DA
CANDIDATE POINT B

FIG. 9(b)

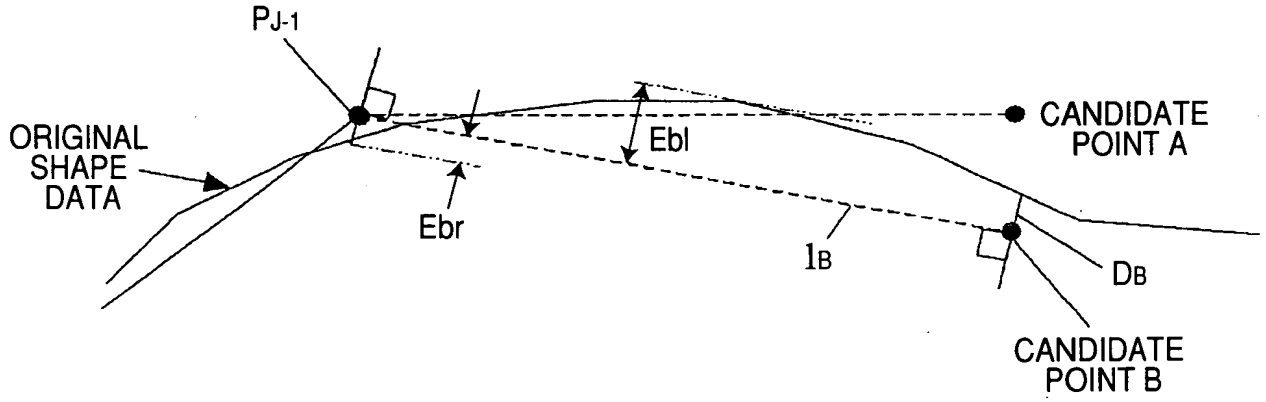

PJ-1
ORIGINAL SHAPE DATA
Ebr
Ebl
lB
CANDIDATE POINT A
DB
CANDIDATE POINT B

FIG. 10

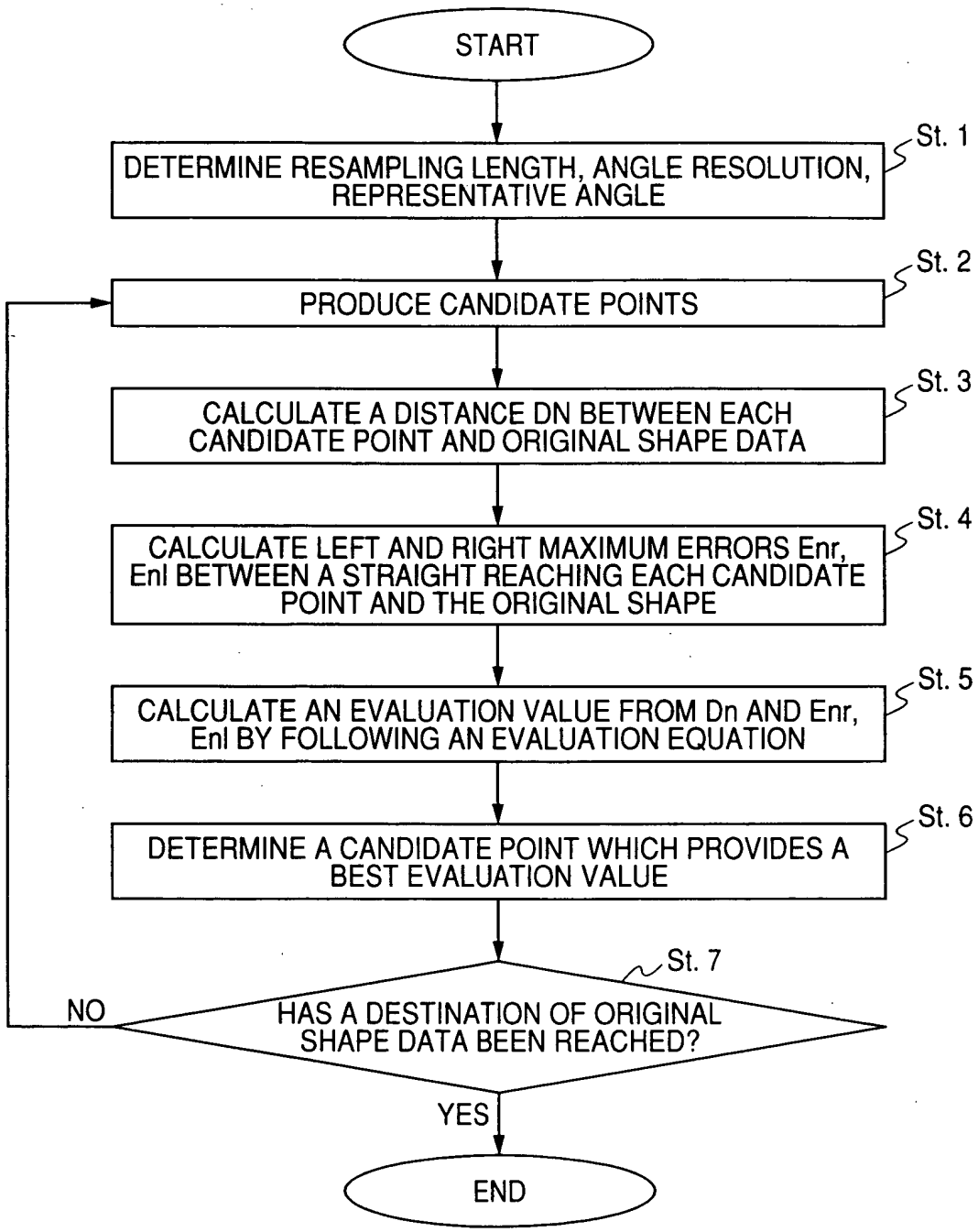

START
DETERMINE RESAMPLING LENGTH, ANGLE RESOLUTION, REPRESENTATIVE ANGLE
St. 1
PRODUCE CANDIDATE POINTS
St. 2
CALCULATE A DISTANCE DN BETWEEN EACH CANDIDATE POINT AND ORIGINAL SHAPE DATA
St. 3
CALCULATE LEFT AND RIGHT MAXIMUM ERRORS Enr, Enl BETWEEN A STRAIGHT REACHING EACH CANDIDATE POINT AND THE ORIGINAL SHAPE
St. 4
CALCULATE AN EVALUATION VALUE FROM Dn AND Enr, Enl BY FOLLOWING AN EVALUATION EQUATION
St. 5
DETERMINE A CANDIDATE POINT WHICH PROVIDES A BEST EVALUATION VALUE
St. 6
St. 7
HAS A DESTINATION OF ORIGINAL SHAPE DATA BEEN REACHED?
NO
YES
END

FIG. 11

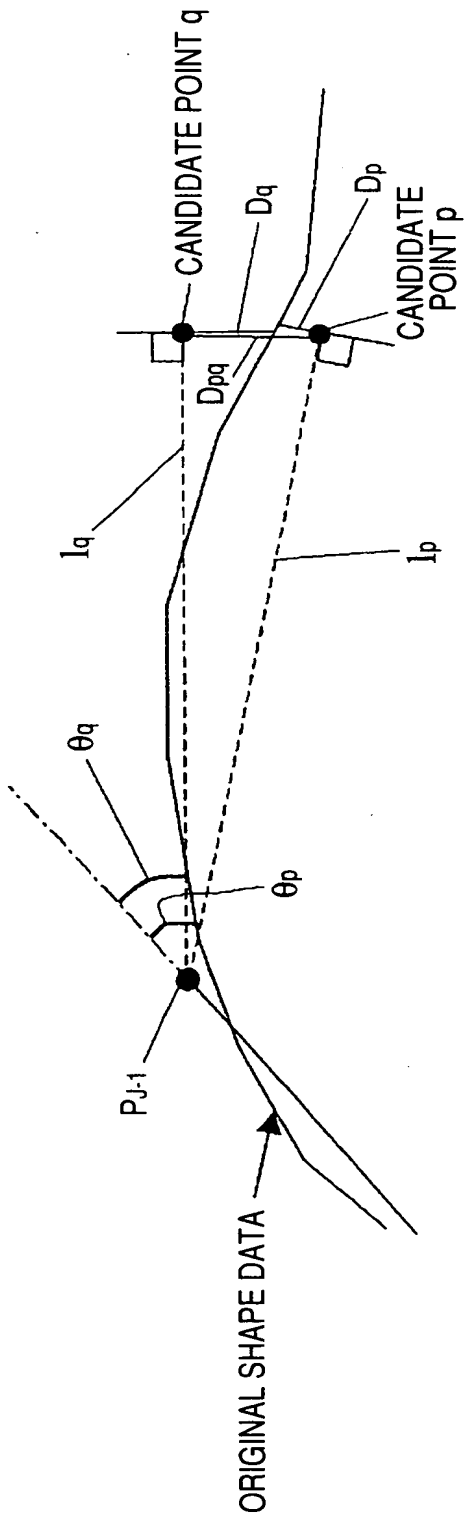

CANDIDATE POINT q
Dq
Dp
CANDIDATE POINT p
Dpq
lq
lp
θq
θp
PJ-1
ORIGINAL SHAPE DATA

FIG. 12

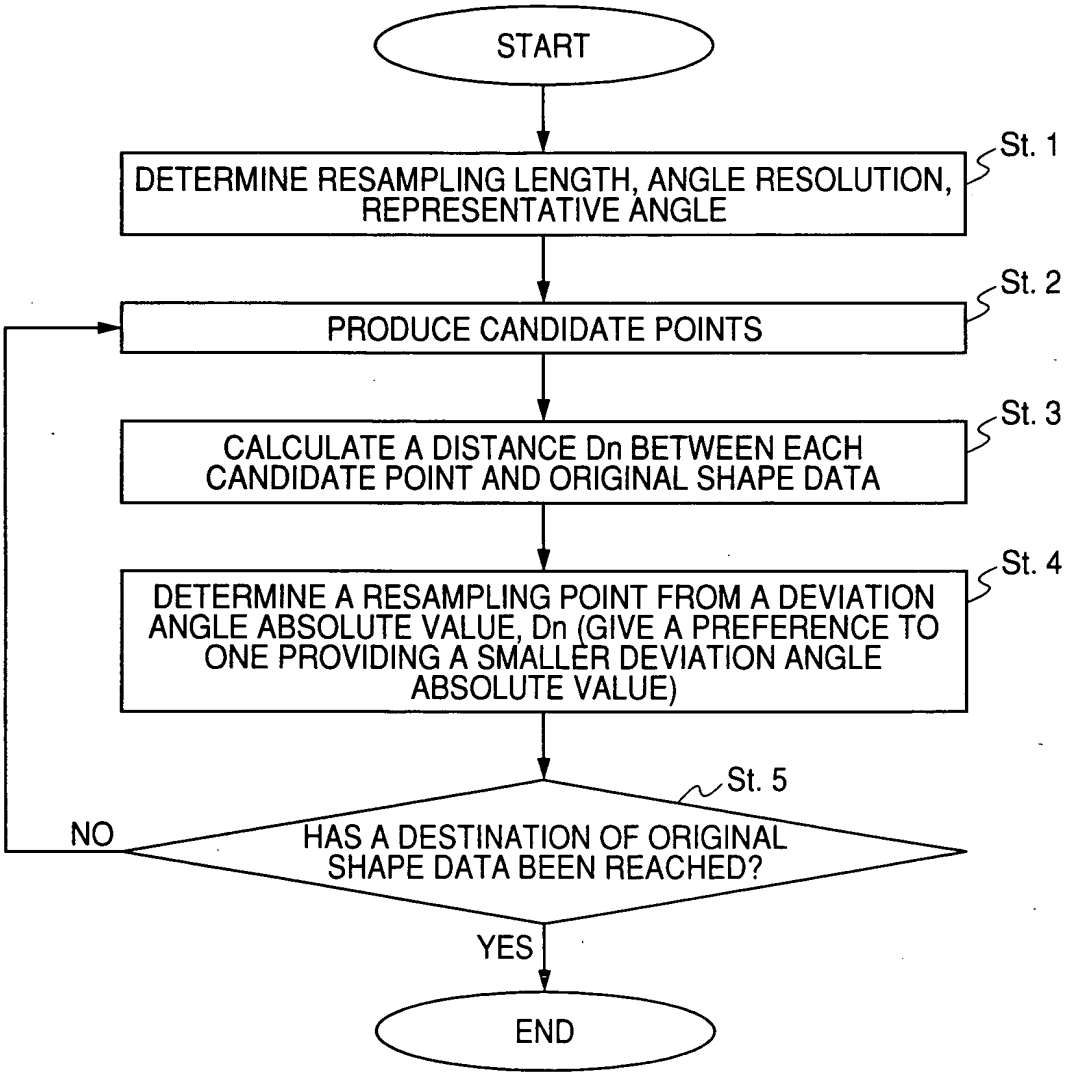

START
DETERMINE RESAMPLING LENGTH, ANGLE RESOLUTION, REPRESENTATIVE ANGLE
St. 1
PRODUCE CANDIDATE POINTS
St. 2
CALCULATE A DISTANCE Dn BETWEEN EACH CANDIDATE POINT AND ORIGINAL SHAPE DATA
St. 3
DETERMINE A RESAMPLING POINT FROM A DEVIATION ANGLE ABSOLUTE VALUE, Dn (GIVE A PREFERENCE TO ONE PROVIDING A SMALLER DEVIATION ANGLE ABSOLUTE VALUE)
St. 4
St. 5
HAS A DESTINATION OF ORIGINAL SHAPE DATA BEEN REACHED?
NO
YES
END

FIG. 13

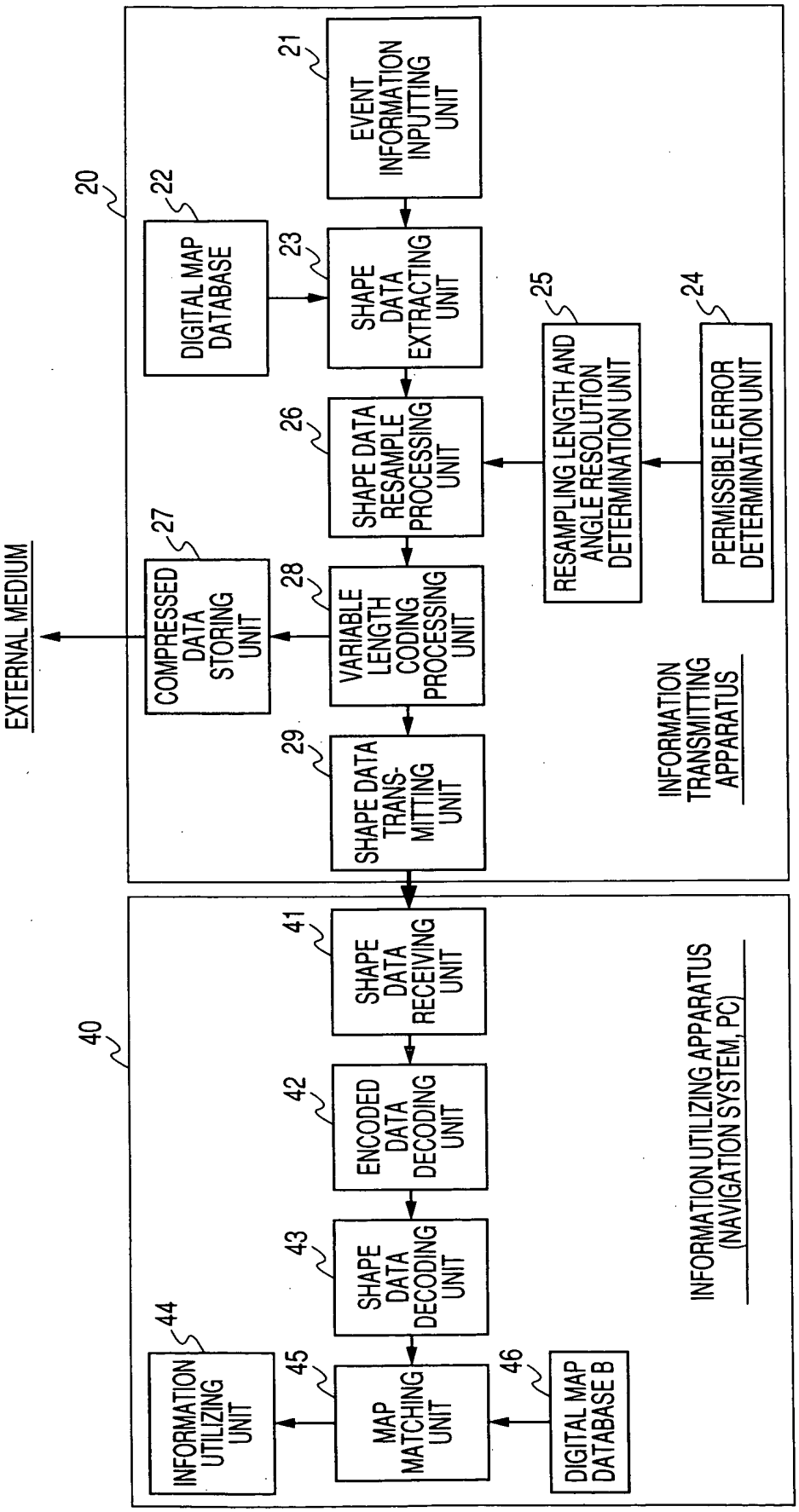

EXTERNAL MEDIUM
20
21
EVENT INFORMATION INPUTTING UNIT
22
DIGITAL MAP DATABASE
23
SHAPE DATA EXTRACTING UNIT
25
RESAMPLING LENGTH AND ANGLE RESOLUTION DETERMINATION UNIT
24
PERMISSIBLE ERROR DETERMINATION UNIT
26
SHAPE DATA RESAMPLE PROCESSING UNIT
27
COMPRESSED DATA STORING UNIT
28
VARIABLE LENGTH CODING PROCESSING UNIT
29
SHAPE DATA TRANS-MITTING UNIT
INFORMATION TRANSMITTING APPARATUS
40
41
SHAPE DATA RECEIVING UNIT
42
ENCODED DATA DECODING UNIT
43
SHAPE DATA DECODING UNIT
44
INFORMATION UTILIZING UNIT
45
MAP MATCHING UNIT
46
DIGITAL MAP DATABASE B
INFORMATION UTILIZING APPARATUS (NAVIGATION SYSTEM, PC)

FIG. 14

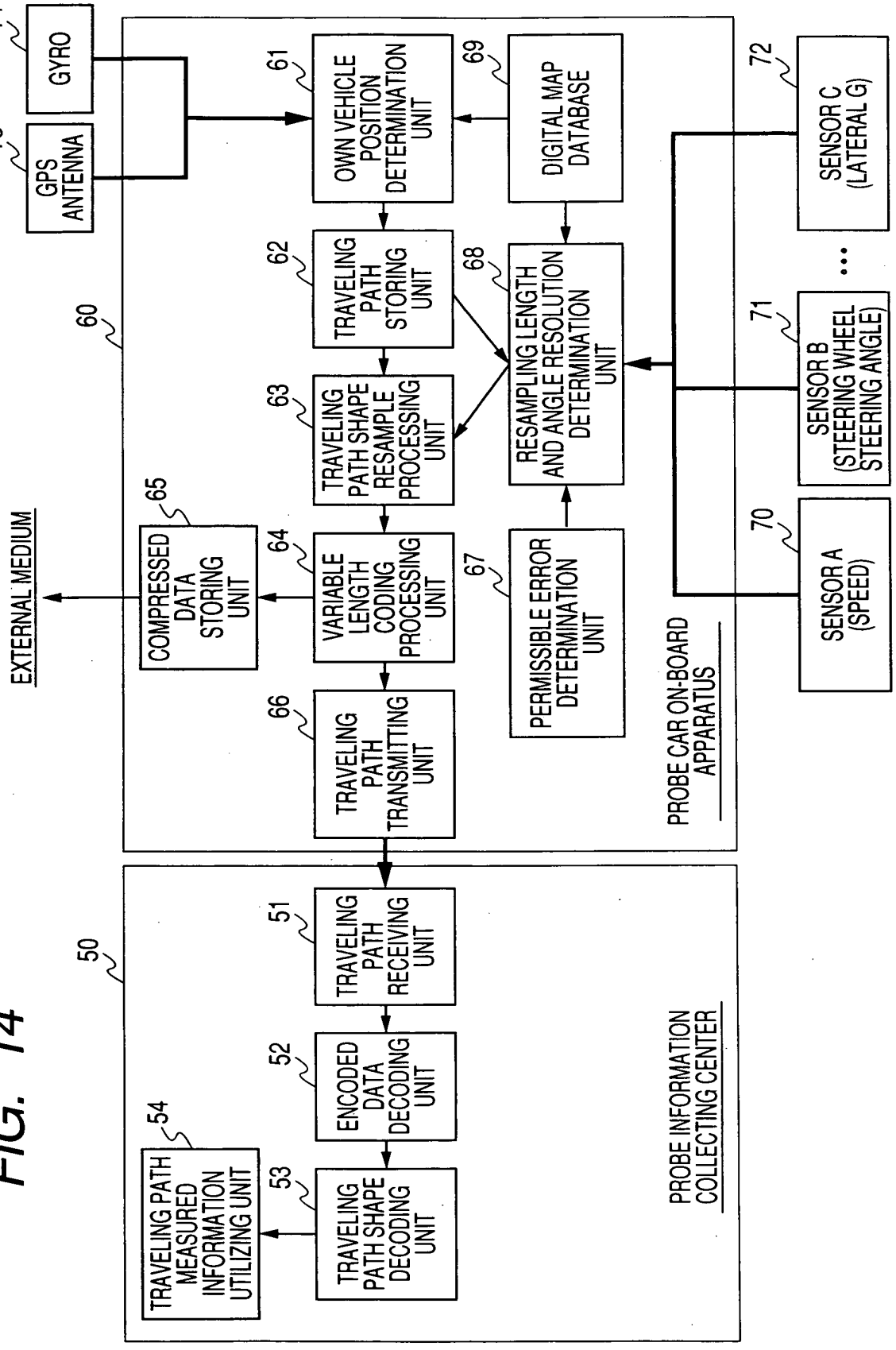

74
GYRO
73
GPS ANTENNA
61
OWN VEHICLE POSITION DETERMINATION UNIT
69
DIGITAL MAP DATABASE
72
SENSOR C (LATERAL G)
60
62
TRAVELING PATH STORING UNIT
68
RESAMPLING LENGTH AND ANGLE RESOLUTION DETERMINATION UNIT
63
TRAVELING PATH SHAPE RESAMPLE PROCESSING UNIT
71
SENSOR B (STEERING WHEEL STEERING ANGLE)
65
COMPRESSED DATA STORING UNIT
64
VARIABLE LENGTH CODING PROCESSING UNIT
67
PERMISSIBLE ERROR DETERMINATION UNIT
70
SENSOR A (SPEED)
EXTERNAL MEDIUM
66
TRAVELING PATH TRANSMITTING UNIT
PROBE CAR ON-BOARD APPARATUS
50
51
TRAVELING PATH RECEIVING UNIT
52
ENCODED DATA DECODING UNIT
54
TRAVELING PATH MEASURED INFORMATION UTILIZING UNIT
53
TRAVELING PATH SHAPE DECODING UNIT
PROBE INFORMATION COLLECTING CENTER

FIG. 15(a)

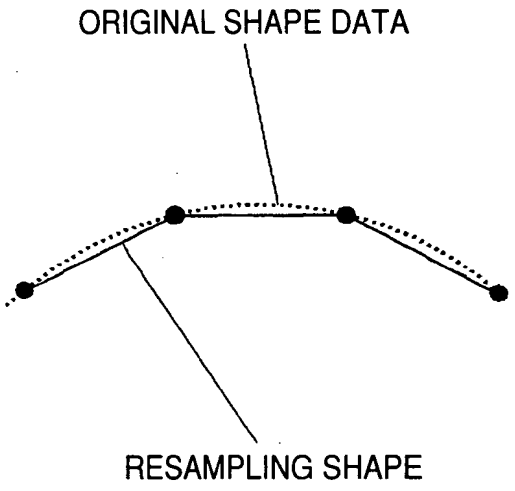


FIG. 15(b)

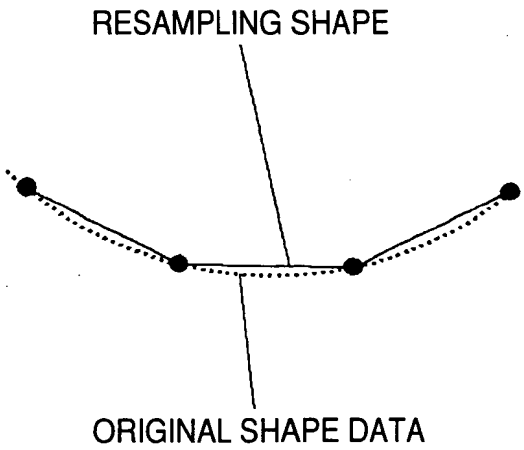


FIG. 16(b)

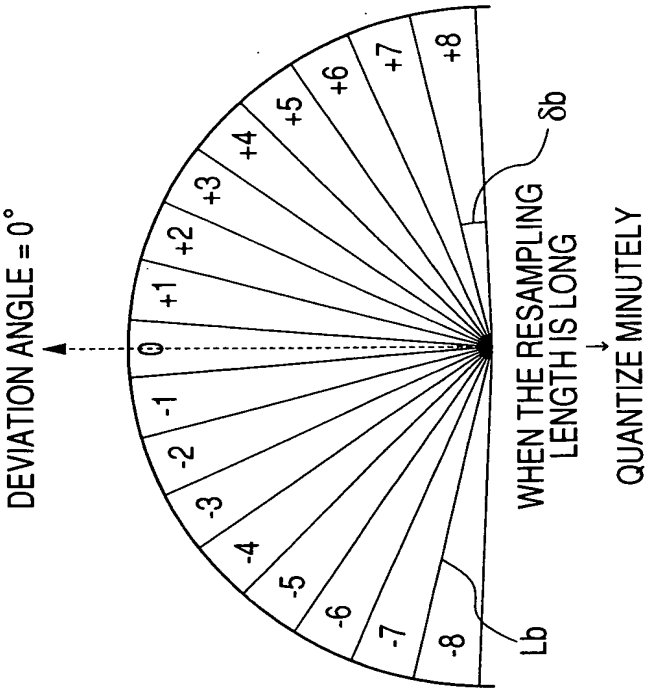


FIG. 16(a)

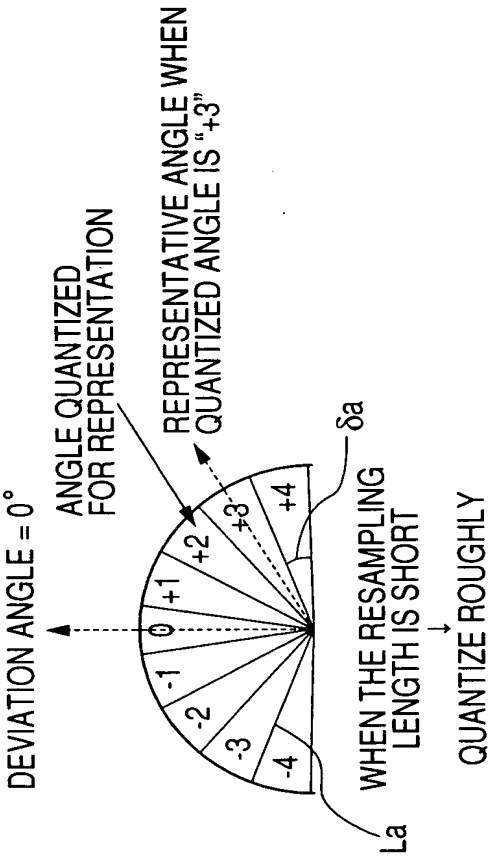


FIG. 17

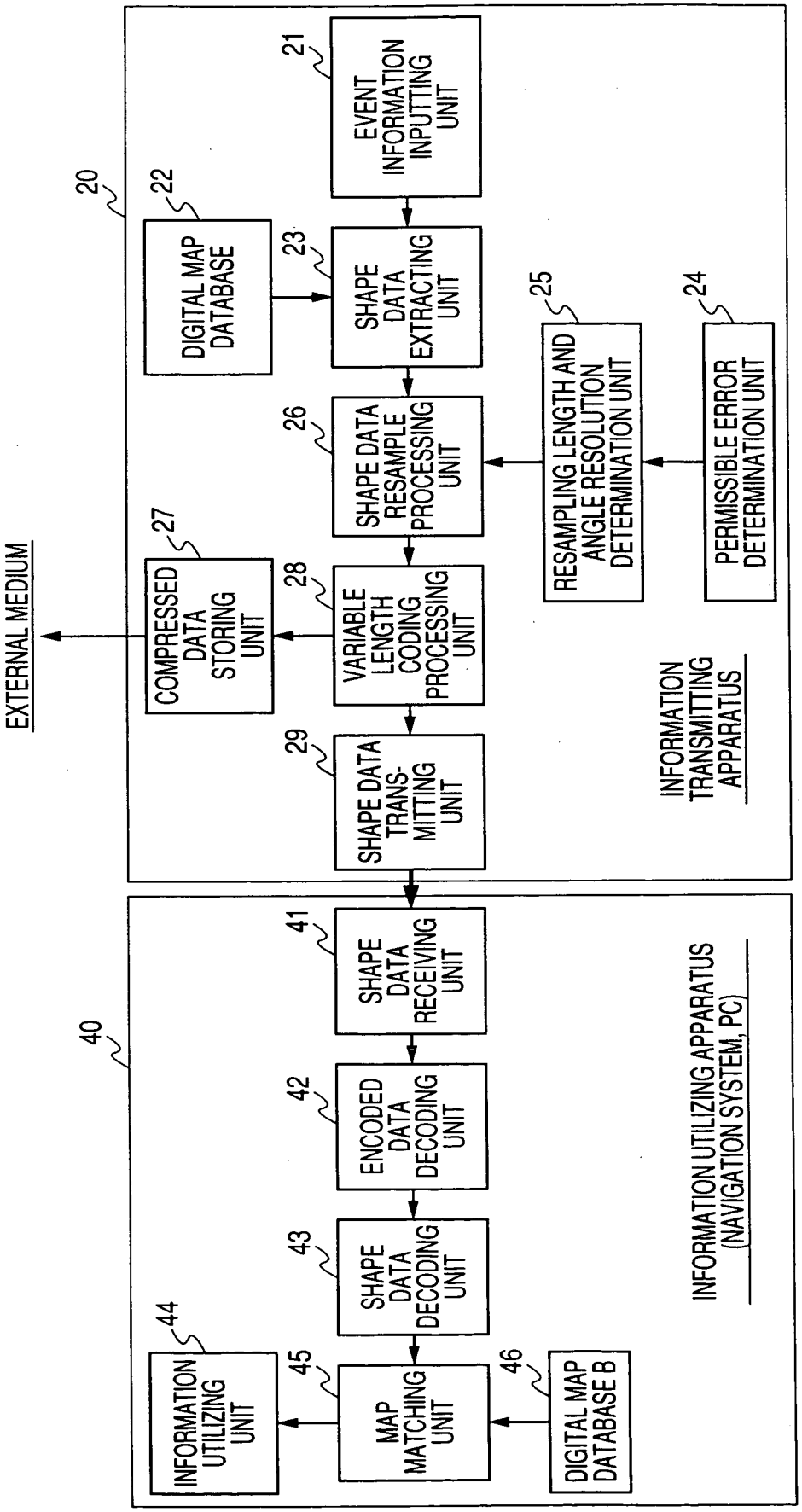

EXTERNAL MEDIUM
20
INFORMATION TRANSMITTING APPARATUS
21
EVENT INFORMATION INPUTTING UNIT
22
DIGITAL MAP DATABASE
23
SHAPE DATA EXTRACTING UNIT
24
PERMISSIBLE ERROR DETERMINATION UNIT
25
RESAMPLING LENGTH AND ANGLE RESOLUTION DETERMINATION UNIT
26
SHAPE DATA RESAMPLE PROCESSING UNIT
27
COMPRESSED DATA STORING UNIT
28
VARIABLE LENGTH CODING PROCESSING UNIT
29
SHAPE DATA TRANS-MITTING UNIT
40
INFORMATION UTILIZING APPARATUS (NAVIGATION SYSTEM, PC)
41
SHAPE DATA RECEIVING UNIT
42
ENCODED DATA DECODING UNIT
43
SHAPE DATA DECODING UNIT
44
INFORMATION UTILIZING UNIT
45
MAP MATCHING UNIT
46
DIGITAL MAP DATABASE B

FIG. 18

RESAMPLING LENGTH (m)	ANGLE RESOLUTION (°) δ
10	6
20	4
40	3
80	2
160	2
320	1
640	1
1280	0.5

FIG. 19

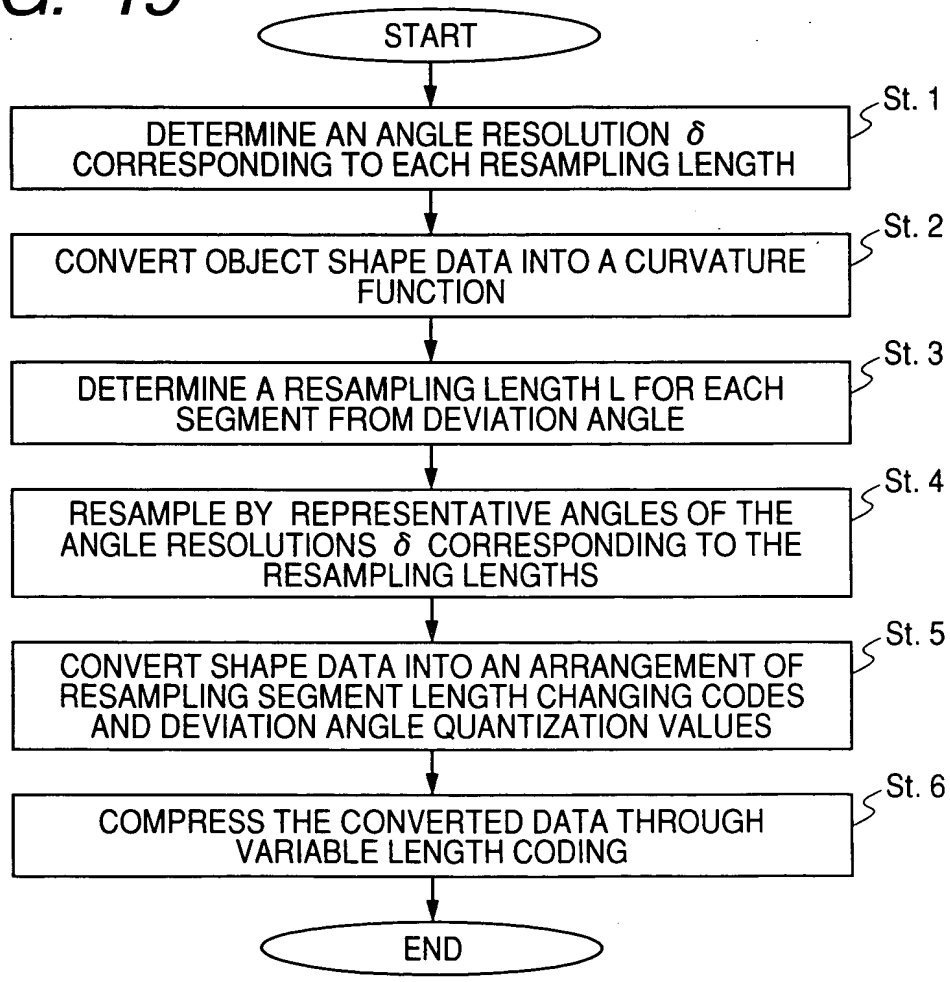


FIG. 20

	←---- DISTANCE ERROR Ea(m) ----→		
L(m)	δ = 1°	δ = 3°	δ = 6°
10	0.09	0.26	0.52
20	0.17	0.52	1.05
40	0.35	1.05	2.09
80	0.70	2.09	4.19
160	1.40	4.19	8.37
320	2.79	8.38	16.75
640	5.58	16.75	33.50
1280	11.17	33.51	66.99

FIG. 21

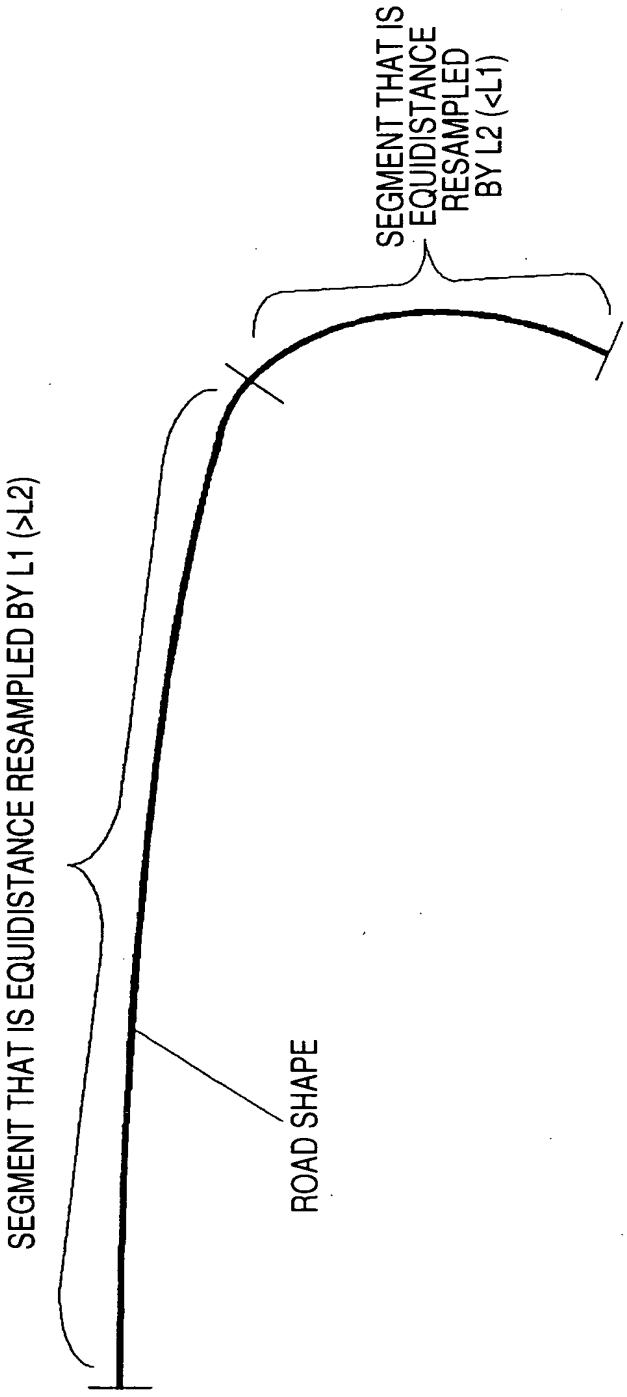

SEGMENT THAT IS EQUIDISTANCE RESAMPLED BY L1 (>L2)
SEGMENT THAT IS EQUIDISTANCE RESAMPLED BY L2 (<L1)
ROAD SHAPE

FIG. 22

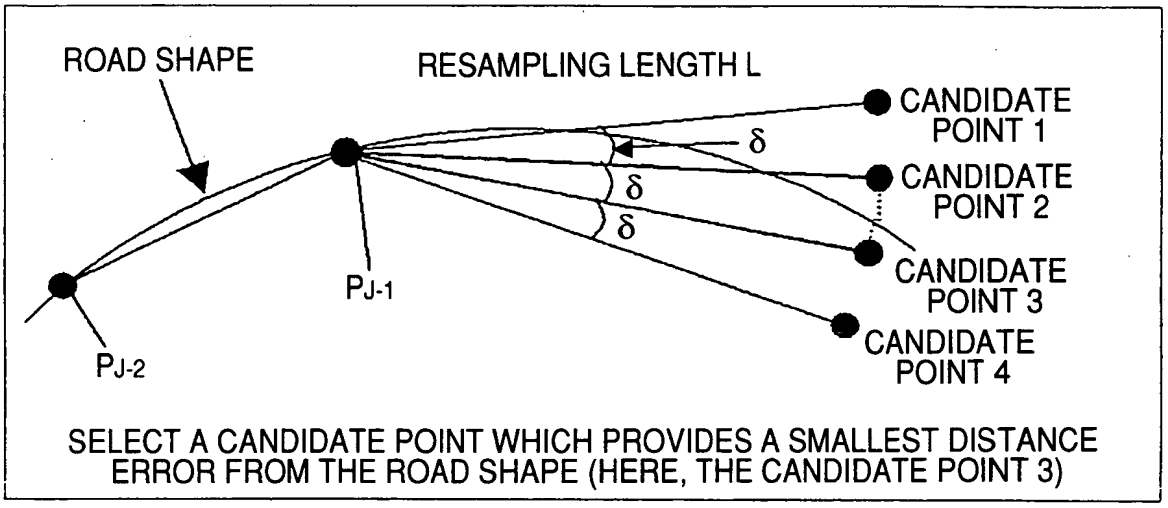
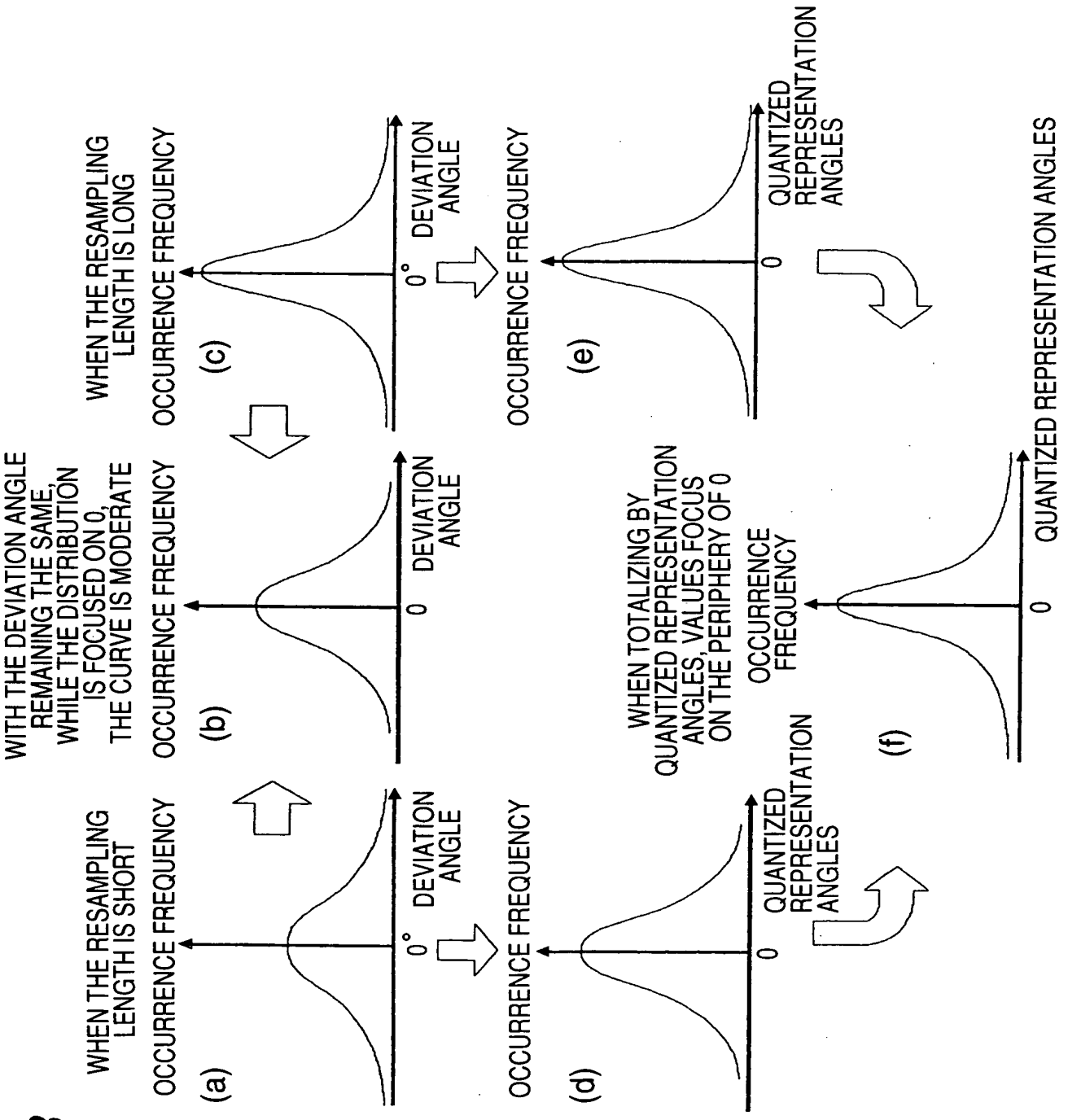

ROAD SHAPE
RESAMPLING LENGTH L
CANDIDATE POINT 1
CANDIDATE POINT 2
CANDIDATE POINT 3
CANDIDATE POINT 4
δ
δ
δ
PJ-1
PJ-2
SELECT A CANDIDATE POINT WHICH PROVIDES A SMALLEST DISTANCE ERROR FROM THE ROAD SHAPE (HERE, THE CANDIDATE POINT 3)

FIG. 23


WHEN THE RESAMPLING LENGTH IS SHORT
OCCURRENCE FREQUENCY
(a)
0°
DEVIATION ANGLE
WITH THE DEVIATION ANGLE REMAINING THE SAME, WHILE THE DISTRIBUTION IS FOCUSED ON 0, THE CURVE IS MODERATE
OCCURRENCE FREQUENCY
(b)
0
DEVIATION ANGLE
WHEN THE RESAMPLING LENGTH IS LONG
OCCURRENCE FREQUENCY
(c)
0°
DEVIATION ANGLE
OCCURRENCE FREQUENCY
(d)
0
QUANTIZED REPRESENTATION ANGLES
WHEN TOTALIZING BY QUANTIZED REPRESENTATION ANGLES, VALUES FOCUS ON THE PERIPHERY OF 0
OCCURRENCE FREQUENCY
(e)
0
QUANTIZED REPRESENTATION ANGLES
OCCURRENCE FREQUENCY
(f)
0
QUANTIZED REPRESENTATION ANGLES

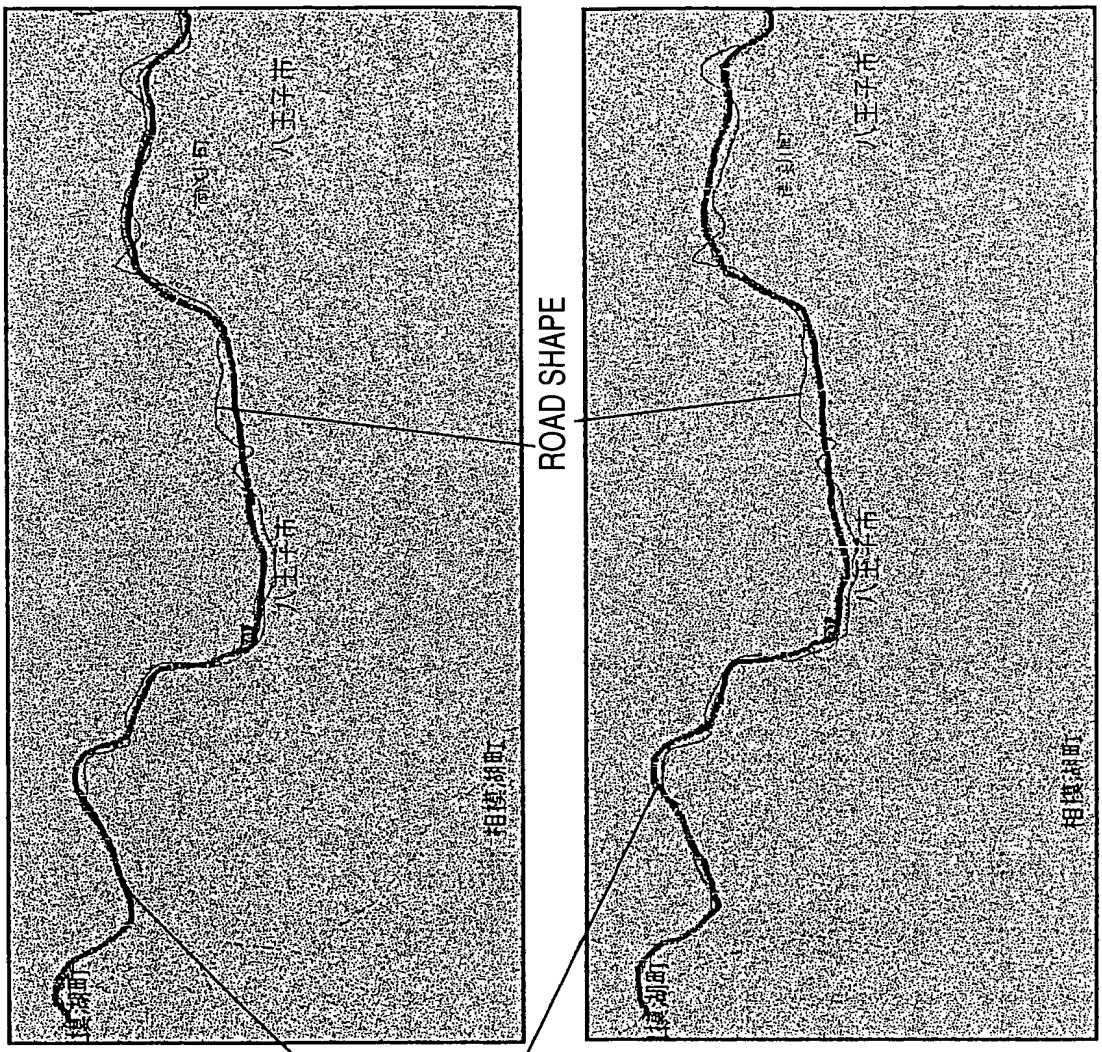


FIG. 24(a)

A ROAD IN A MOUNTAINOUS AREA WHOSE RESAMPLING LENGTH IS SHORT
$\delta = 2$
$Kr = 0.4$

FIG. 24(b)

A ROAD IN A MOUNTAINOUS AREA WHOSE RESAMPLING LENGTH IS SHORT
$\delta = 6$
$Kr = 0.4$

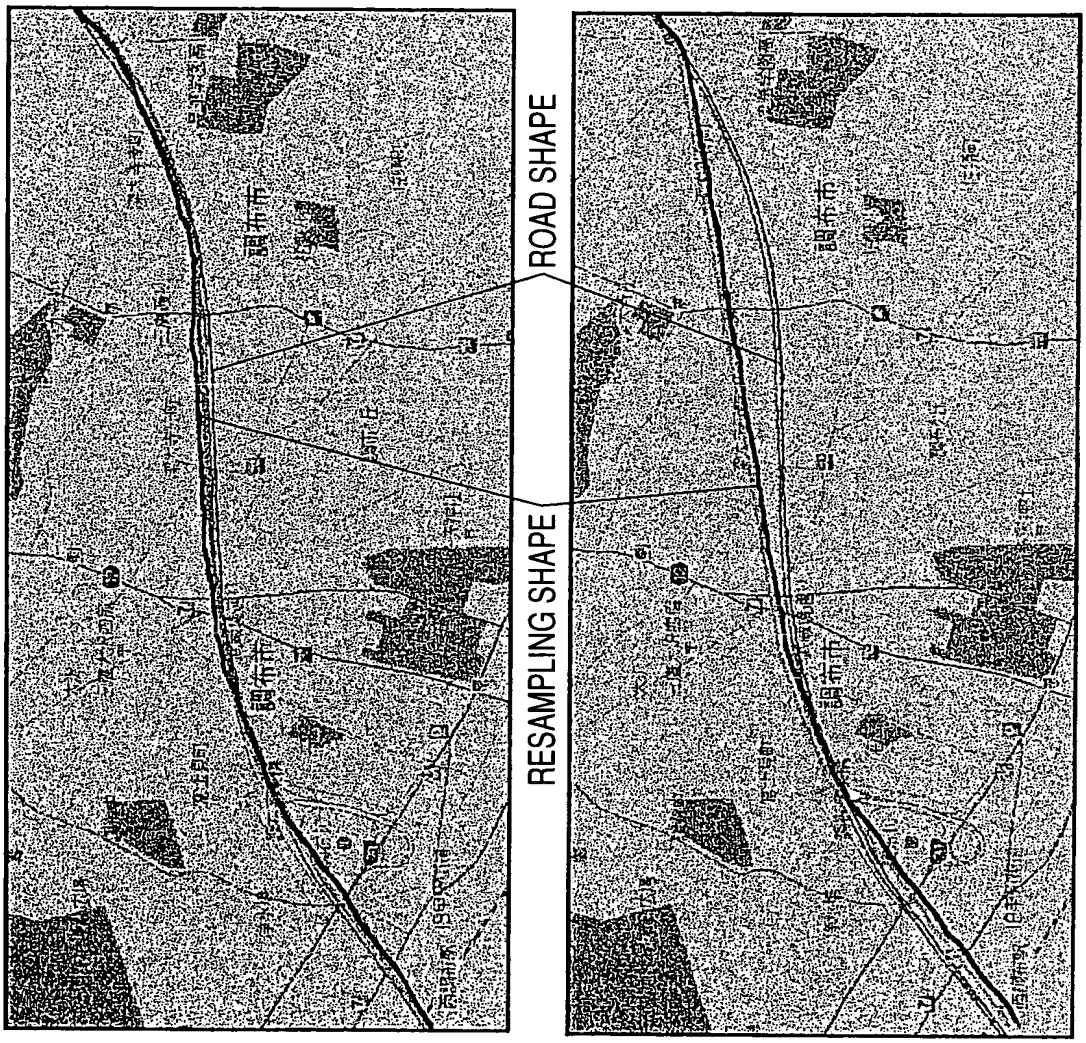


FIG. 25(a)

A HIGHWAY WHOSE RESAMPLING LENGTH IS LONG
$\delta = 2$
$Kr = 0.4$

FIG. 25(b)

A HIGHWAY WHOSE RESAMPLING LENGTH IS LONG
$\delta = 6$
$Kr = 0.4$

FIG. 26

	$\delta = 2°$	$\delta = 6°$
• A ROAD IN A MOUNTAINOUS AREA	1042bit	790bit
• A HIGHWAY	182bit	88bit

FIG. 27(a)

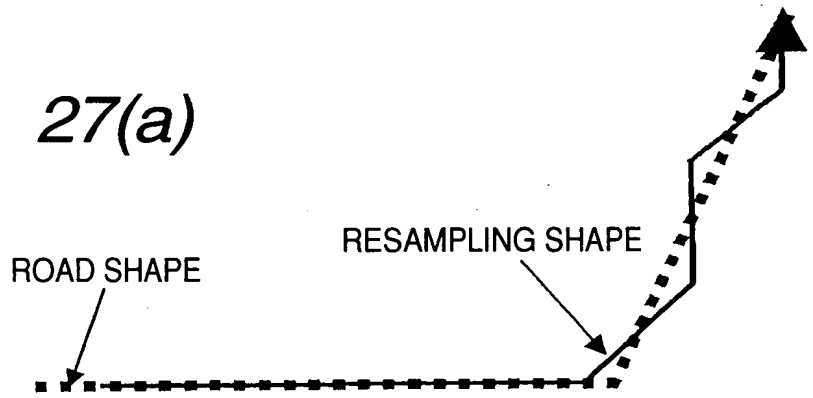


FIG. 27(b)

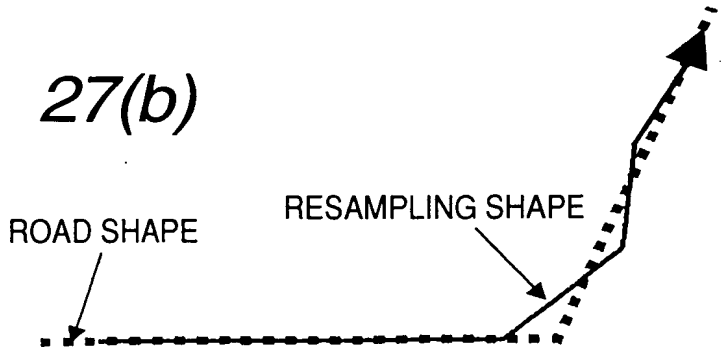


FIG. 28

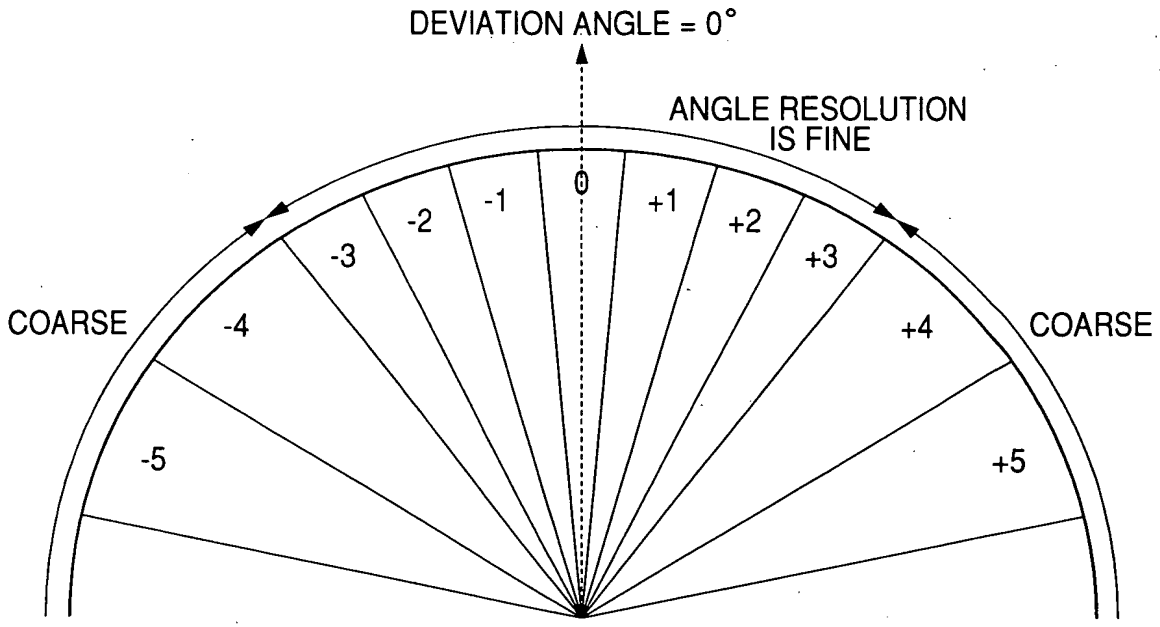


FIG. 29

RESAMPLING LENGTH (m)	ANGLE RESOLUTION (°) $\lvert\theta\rvert \leq 10$	ANGLE RESOLUTION (°) $10 < \lvert\theta\rvert \leq 60$	ANGLE RESOLUTION (°) $60 < \lvert\theta\rvert$
10	6	10	30
20	4	6	20
40	3	6	10
80	2	4	4
160	2	2	4
320	1	1	2
640	1	1	2
1280	0.5	0.5	1

FIG. 30

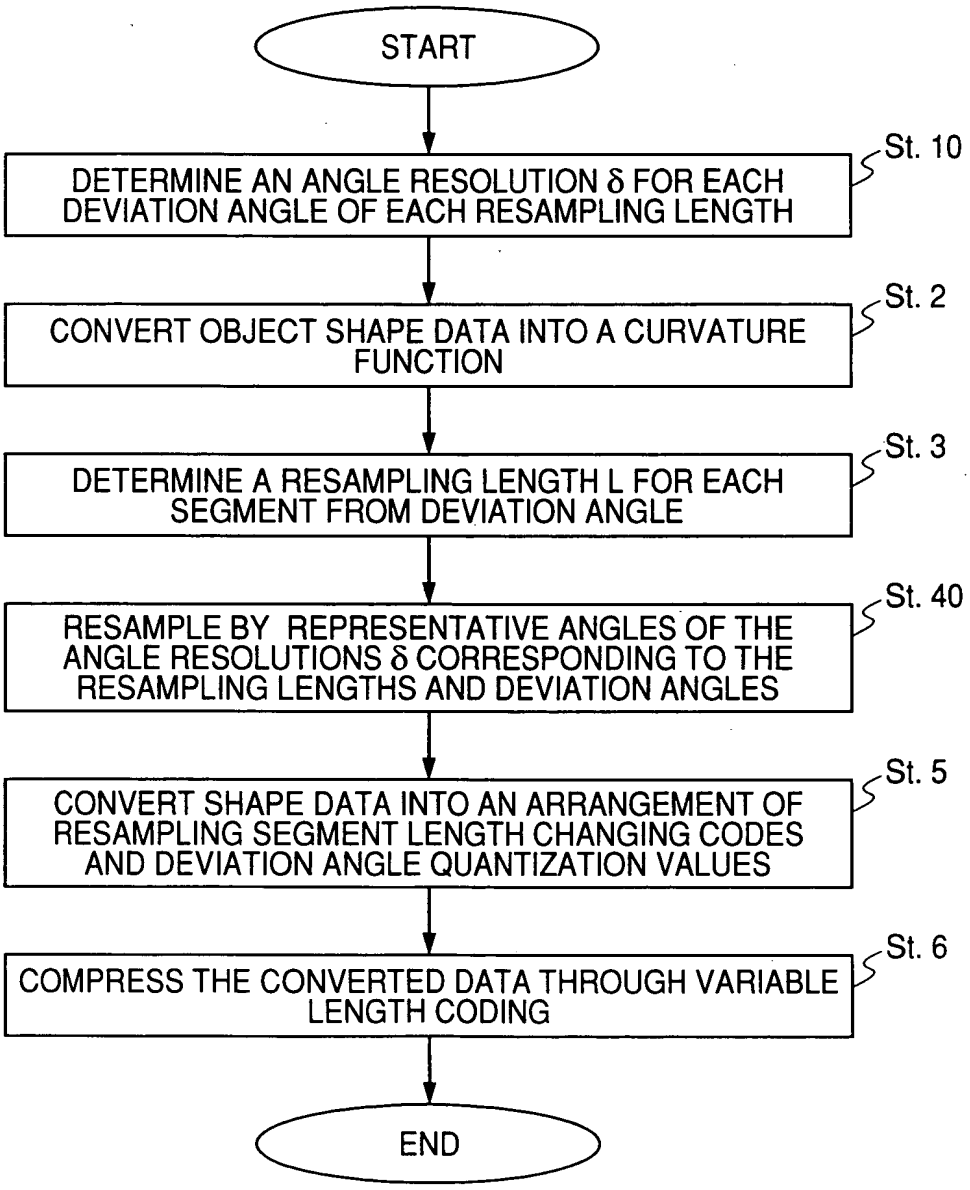

START
DETERMINE AN ANGLE RESOLUTION δ FOR EACH DEVIATION ANGLE OF EACH RESAMPLING LENGTH
St. 10
CONVERT OBJECT SHAPE DATA INTO A CURVATURE FUNCTION
St. 2
DETERMINE A RESAMPLING LENGTH L FOR EACH SEGMENT FROM DEVIATION ANGLE
St. 3
RESAMPLE BY REPRESENTATIVE ANGLES OF THE ANGLE RESOLUTIONS δ CORRESPONDING TO THE RESAMPLING LENGTHS AND DEVIATION ANGLES
St. 40
CONVERT SHAPE DATA INTO AN ARRANGEMENT OF RESAMPLING SEGMENT LENGTH CHANGING CODES AND DEVIATION ANGLE QUANTIZATION VALUES
St. 5
COMPRESS THE CONVERTED DATA THROUGH VARIABLE LENGTH CODING
St. 6
END

FIG. 31

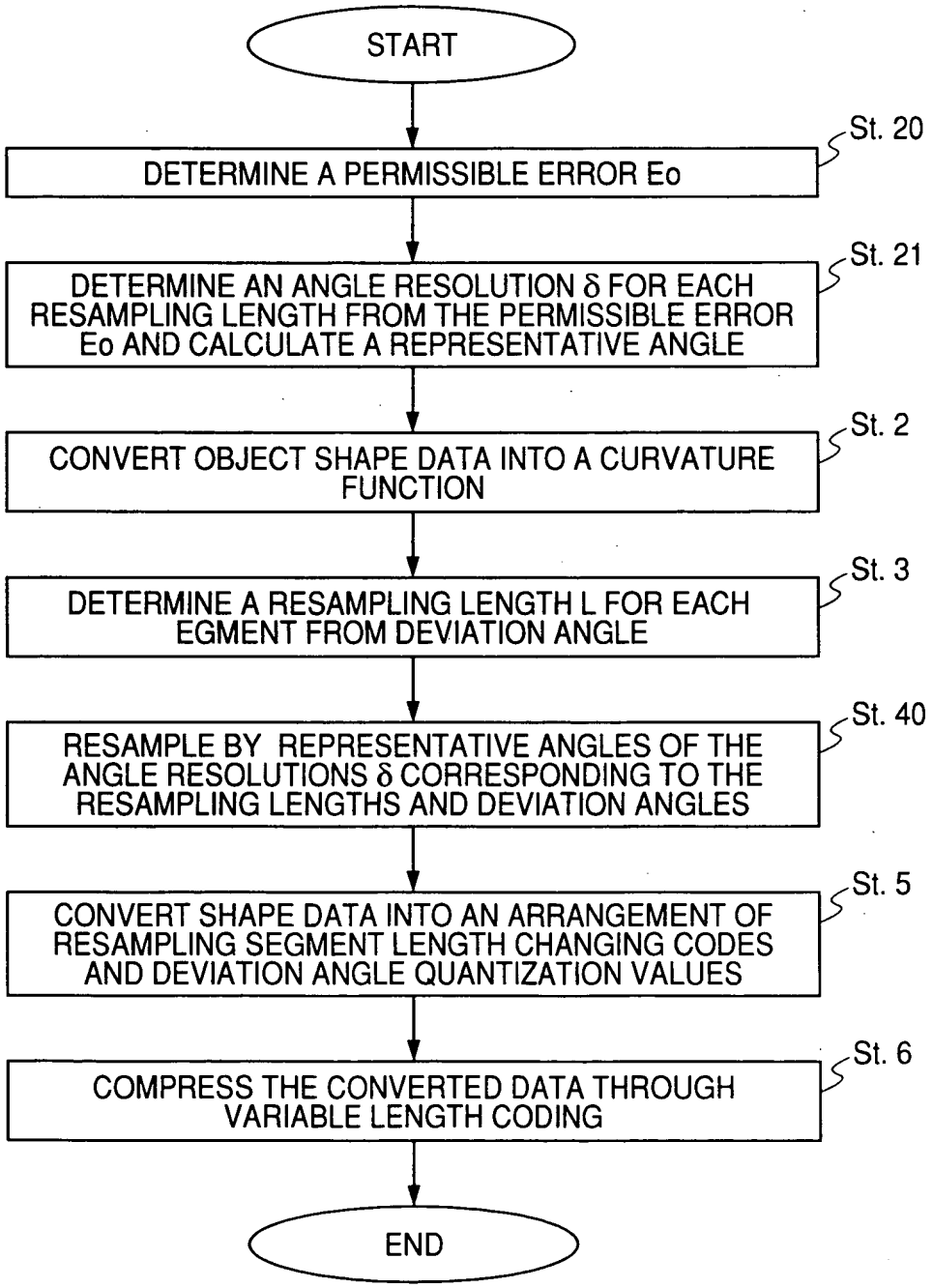

START
St. 20
DETERMINE A PERMISSIBLE ERROR Eo
St. 21
DETERMINE AN ANGLE RESOLUTION δ FOR EACH RESAMPLING LENGTH FROM THE PERMISSIBLE ERROR Eo AND CALCULATE A REPRESENTATIVE ANGLE
St. 2
CONVERT OBJECT SHAPE DATA INTO A CURVATURE FUNCTION
St. 3
DETERMINE A RESAMPLING LENGTH L FOR EACH EGMENT FROM DEVIATION ANGLE
St. 40
RESAMPLE BY REPRESENTATIVE ANGLES OF THE ANGLE RESOLUTIONS δ CORRESPONDING TO THE RESAMPLING LENGTHS AND DEVIATION ANGLES
St. 5
CONVERT SHAPE DATA INTO AN ARRANGEMENT OF RESAMPLING SEGMENT LENGTH CHANGING CODES AND DEVIATION ANGLE QUANTIZATION VALUES
St. 6
COMPRESS THE CONVERTED DATA THROUGH VARIABLE LENGTH CODING
END

FIG. 32

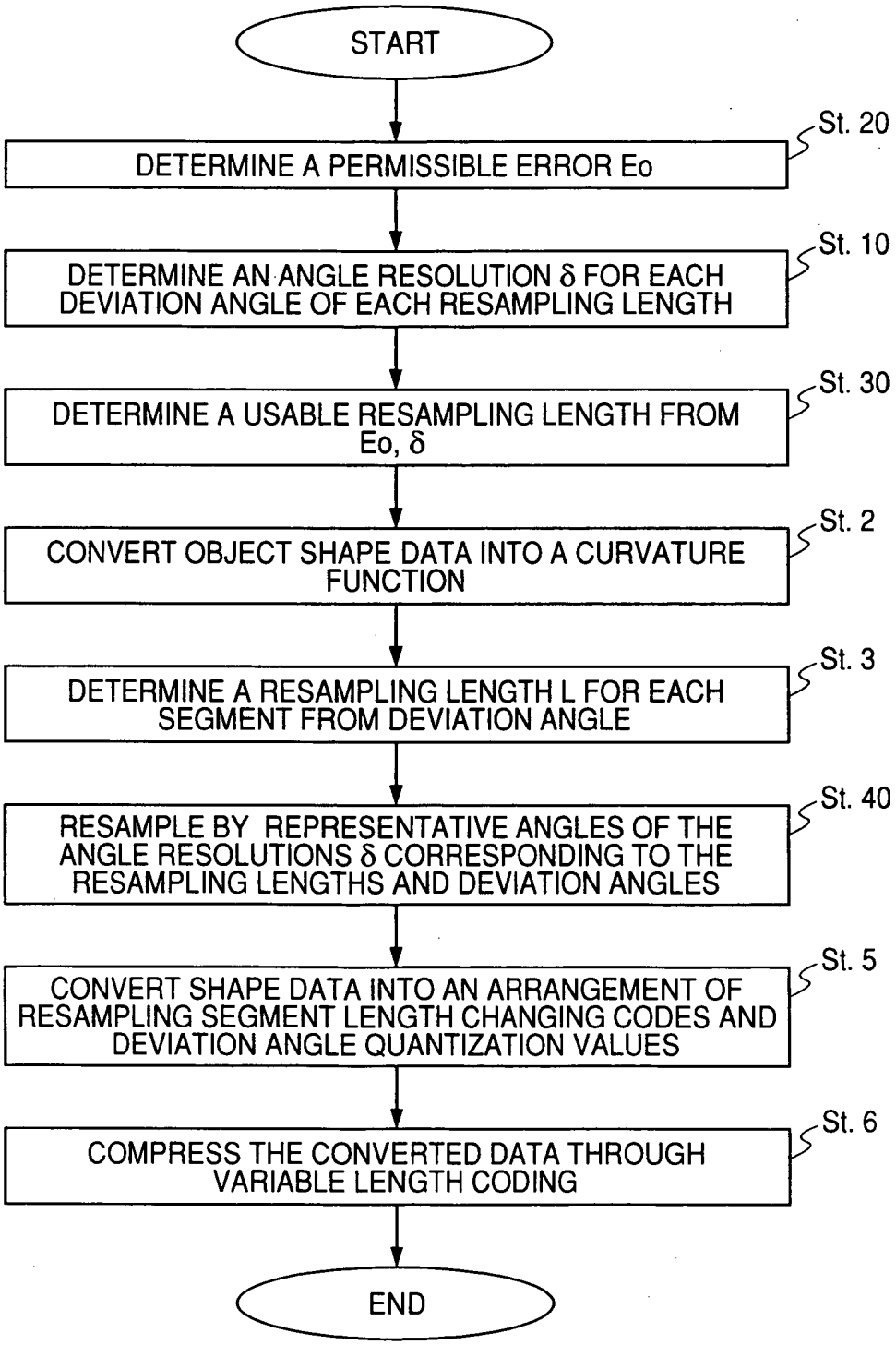

START
St. 20
DETERMINE A PERMISSIBLE ERROR Eo
St. 10
DETERMINE AN ANGLE RESOLUTION δ FOR EACH DEVIATION ANGLE OF EACH RESAMPLING LENGTH
St. 30
DETERMINE A USABLE RESAMPLING LENGTH FROM Eo, δ
St. 2
CONVERT OBJECT SHAPE DATA INTO A CURVATURE FUNCTION
St. 3
DETERMINE A RESAMPLING LENGTH L FOR EACH SEGMENT FROM DEVIATION ANGLE
St. 40
RESAMPLE BY REPRESENTATIVE ANGLES OF THE ANGLE RESOLUTIONS δ CORRESPONDING TO THE RESAMPLING LENGTHS AND DEVIATION ANGLES
St. 5
CONVERT SHAPE DATA INTO AN ARRANGEMENT OF RESAMPLING SEGMENT LENGTH CHANGING CODES AND DEVIATION ANGLE QUANTIZATION VALUES
St. 6
COMPRESS THE CONVERTED DATA THROUGH VARIABLE LENGTH CODING
END

FIG. 33

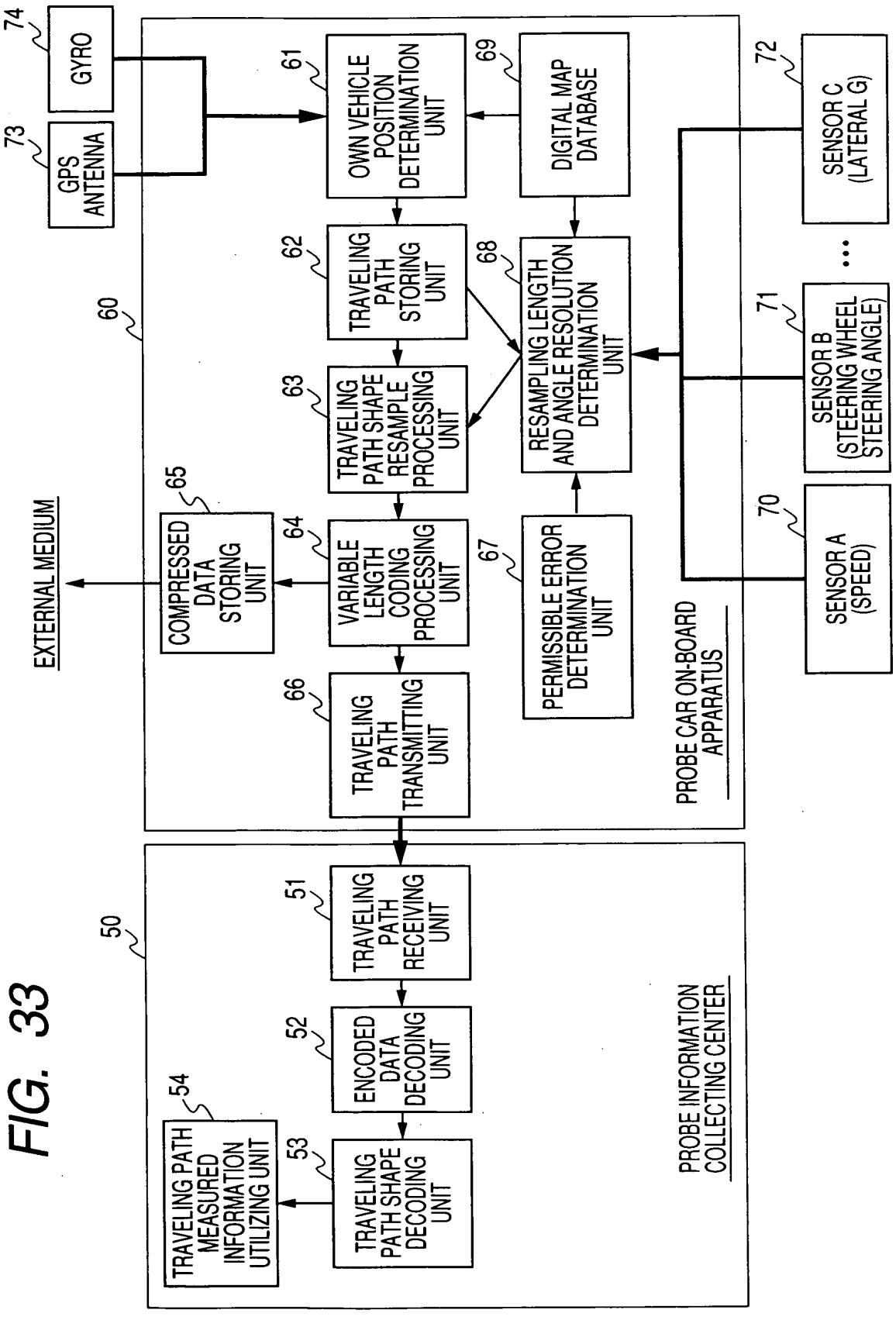
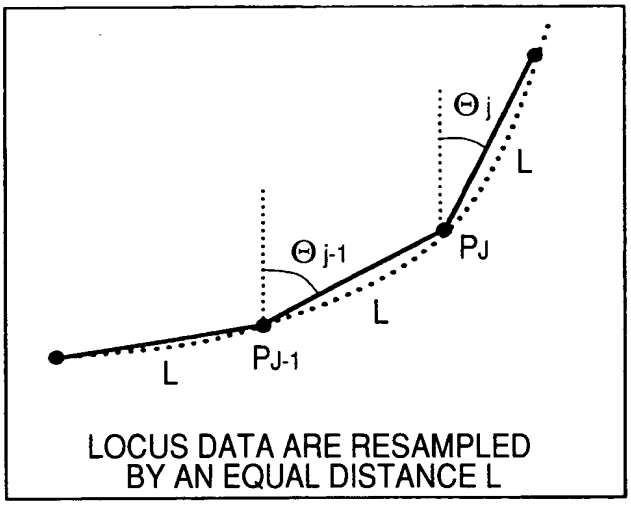
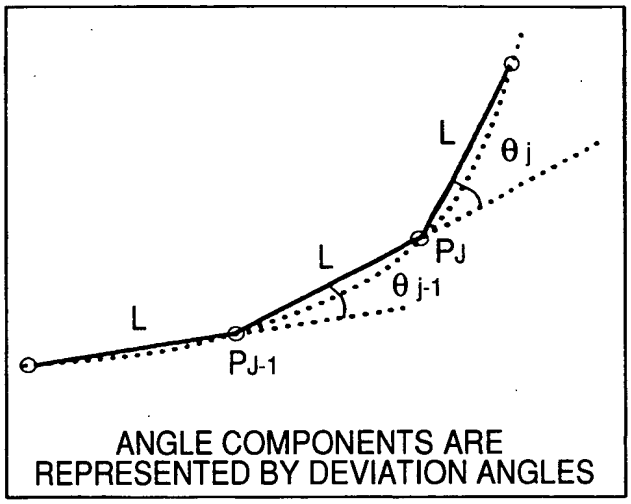

74
GYRO
73
GPS ANTENNA
61
OWN VEHICLE POSITION DETERMINATION UNIT
69
DIGITAL MAP DATABASE
72
SENSOR C (LATERAL G)
60
62
TRAVELING PATH STORING UNIT
68
RESAMPLING LENGTH AND ANGLE RESOLUTION DETERMINATION UNIT
63
TRAVELING PATH SHAPE RESAMPLE PROCESSING UNIT
71
SENSOR B (STEERING WHEEL STEERING ANGLE)
65
COMPRESSED DATA STORING UNIT
64
VARIABLE LENGTH CODING PROCESSING UNIT
67
PERMISSIBLE ERROR DETERMINATION UNIT
70
SENSOR A (SPEED)
EXTERNAL MEDIUM
66
TRAVELING PATH TRANSMITTING UNIT
PROBE CAR ON-BOARD APPARATUS
50
51
TRAVELING PATH RECEIVING UNIT
52
ENCODED DATA DECODING UNIT
54
TRAVELING PATH MEASURED INFORMATION UTILIZING UNIT
53
TRAVELING PATH SHAPE DECODING UNIT
PROBE INFORMATION COLLECTING CENTER

FIG. 34(a)



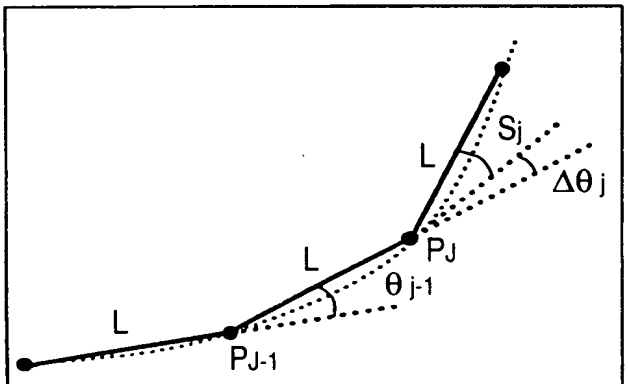
LOCUS DATA ARE RESAMPLED BY AN EQUAL DISTANCE L

FIG. 34(b)



ANGLE COMPONENTS ARE REPRESENTED BY DEVIATION ANGLES

FIG. 34(c)



DEVIATION ANGLES ARE REPRESENTED BY STATISTICALLY ESTIMATED DIFFERENCE VALUES

FIG. 34(d)

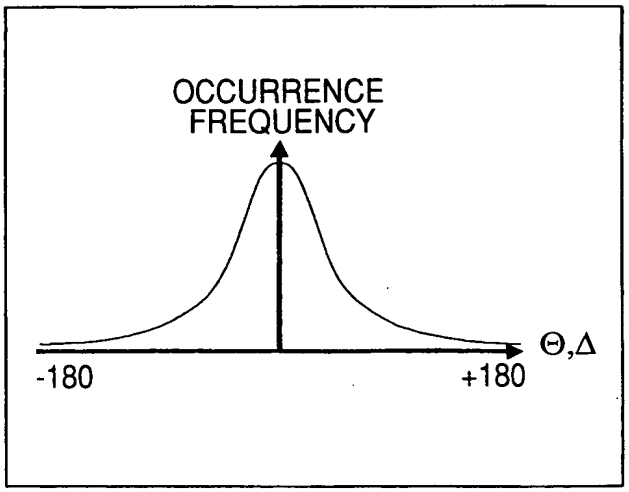


FIG. 35

SPECIAL CODES		CODES	ADDITIONAL BITS	
EOD CODES		1100	0	
INPUT VALUES		CODES	ADDITIONAL BITS	RANGES (°) OF Δθ VALUES
RUN LENGTHS	VALUES OF Δθ (°)			
0	0	0	0	-1~+1
5	0	100	0	"
10	0	1101	0	"
0	± 3	1110	1 (± IDENTIFICATION)	± 2~4
0	± 6	111100	1 (± IDENTIFICATION)	± 5~7
0	± 9	111101	1 (± IDENTIFICATION)	± 8~10
≀				

FIG. 36

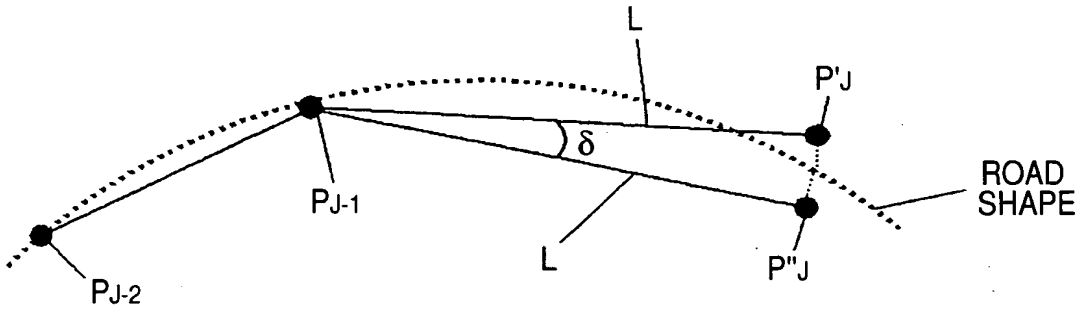
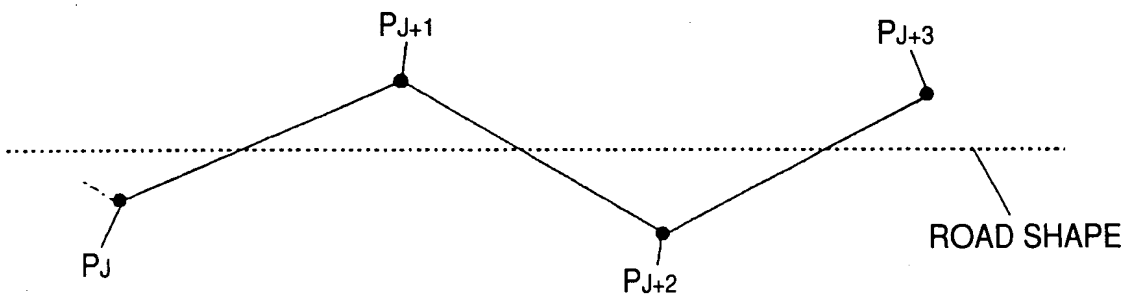


FIG. 37



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